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EDITORIAL

Education for Farmers

FROM a member of more than thirty years in the American Society of Agricultural Engineers, a man with unusual observation and insight into the social and economic aspects of agriculture as well as its engineering, has come a suggestion for a new approach to higher education for farm people. We make bold to add thoughts of our own.

His idea is that many farmers could get away from the farm for a straight three months of real college work, if the term or quarter were properly timed into the crop cycle. He does not minimize the value of extension work nor of resident short courses, though of the latter he observes that the students go back home before they have learned their way around the campus. In his measured judgment, the major value of his proposal is in getting the farmer for three months away from the environment of the farm and into the academic atmosphere.

He believes that such farmers would go back to their farms with a new and broader perspective on the place of farming in the nation's economy. He believes they will be better farmers, able to plan more wisely with a vision of national and world needs, as well as being more expert in some specific phases of farm technology. They should be freed from the feeling that the world of education is something from which they are excluded.

We see in his proposal something still greater. We see a chance to make the farmer not merely a more efficient tiller of soil and swiller of swine, but an educated man. In the company of keen minds and under the stimulation of a scholar he could roll back the centuries and scan the rise and fall of civilizations. He might make systematic study of classical economics or of political science. According to his taste and talent he could take up intensively one or another of the humanities.

In the unfolding American scene there is need for educated men in agriculture. No longer a majority able to hold its place by brute force of numbers, agriculture must make its way by the caliber of its citizens. Pending the time when a regular college course is routine for farm youth, the winter term of regular college participation would be a stride in the right direction. We commend the proposal for discussion and for development.

Surplus and Salvage

APPARENTLY the time is rapidly approaching when there will be a big job, not to say a problem, of liquidating huge stores of materials left over from military and other government purchases. Agriculture and its engineeers have interests, both special and general, in the policy and procedure of such disposal.

In the training centers are large amounts of temporary construction, largely of lumber. Much of this material, including electric wiring, windows, etc., if efficiently salvaged and intelligently distributed could well be woven into the program of farm building and remodeling so greatly needed. Obviously it should be utilized, so far as practicable, close by the points where it happens to be. Unfortunately the methods of government auctions or other sales do not lend themselves to practical patronage by individual farmers or local contractors.

Efficient procedure would be to get these materials as directly as possible into the permanent channels of distribution — the brokers, wholesalers and retailers of building materials and supplies. We see no sense in holding these established and efficient distribution streams stagnant while building up a bureaucracy to by-pass them. The sooner we get the machinery of private business into high gear, the quicker and smoother will be the transition to the economy of peace.

It is important, of course, to utilize such salvage and surplus materials in an orderly fashion without disrupting the production of new materials in reasonable volume. We envision the surpluses being fed into the stream of regular business rather slowly and steadily, like the tailings coming back to the cylinder of a thresher. Resumption of an active private business economy promises more benefit to agriculture than could come from special subsidies in the form of abnormally low prices for materials sold to farmers.

Example for the procedure to be followed is furnished by the system of prime contractors and subcontractors in war production. Let concerns big enough and experienced enough in dealing with government methods buy the camps or stockpiles as whole units. Let them peddle the stuff out into established channels of trade. Let there be competition in purchasing and in selling. If they manage to make a good profit, so much the better. The government will take most of it in taxes and thereby ease by that much the burden on every citizen.

Let's Have Profits

INCREDIBLE in a more or less educated country, and obviously illogical, is the prevalent feeling that a prime purpose of government is the prevention of profit. Waste, inefficiency, corruption and fantastic costs can be forgiven, but not the earning of a profit. Even when 95 per cent of the profit is recaptured in taxes, the mere earning of the profit arouses revulsion.

Perhaps the psychologists can explain this emotional quirk. As engineers we can only do our bit to combat it. It may seem silly to point out the obvious, but it also seems necessary. With a federal debt of some 200 billion to be borne, there is a lot of taxpaying to do. As long as corporation earnings are taxed 50 to 95 per cent, before the residue is again taxed as stockholder's income, the logical prayer by engineer and patriot would be for higher and better profits.

Important as is the problem of federal revenue, that of employment is even more urgent. We cannot go all the way with those wishful thinkers who hope to have war employment without a war and war wages without regard to treasury deficits. We can discount their hopes and promises to a reasonable peacetime level and still be concerned about employment.

Despite all its sins, actual and alleged, the only thing that can pay both wages and taxes is private business. Only when private business is high in volume are both farm products and the services of labor in brisk demand. Only when there is at least a hope of profit does business wax strong enough to bid well for the full fruits of land and labor.

As we face the era of demobilization and readjustment, it is only common sense for the common man to insist that public policy give the green light to private business. For purposes of public policy it is immaterial whether it be big business or small business, corporate, cooperative, or individual. The criteria are (1) whether it carries its full load of taxes, and (2) whether it has the opportunity and the objective of growing by its own earnings, i.e., profits.

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Some Concepts of Farming Efficiency

By G. B. Gunlogson

MEMBER A.S.A.E.

ENGINEERS define efficiency as the "ratio between effect produced and energy expended." What I want to discuss in this paper are some concepts of farming efficiency in a broad sense, especially the ratio between what we get out of agriculture and what we are putting into it.

When it is desired to convey the conception of efficiency in farming, it is quite common among us to employ a device which expresses some optimum performance. For example, we may say that a bushel of corn can now be produced with 3 min of man labor, or that a man now produces 4 bu of wheat in the time required for 1 bu fifty years ago.

To the man in the street this is a spectacular performance, but it does not have the same reaction at all on the farmer. He knows there are many factors between paper efficiency and farm production which are beyond human control. Then there is another set of factors of agricultural-mechanical-economic nature which he often finds difficult and sometimes impossible to solve. They are essentially the limiting factors in farming efficiency and mechanical efficiency.

There are two ways of measuring or considering how efficient machinery has actually made the farmer of today. One way is to employ statistics. We can show what it took in the way of machinery, horses, mules and men to operate our farms last year, or ten or twenty years ago. By more arithmetic this can be brought down to an acre or bushel basis, to a unit farm, or to an individual worker.

The second method is to go out and make a close study of what individual farmers are doing, or try it out for ourselves where we can use our own judgment and take our own chances with the results. If we go into any farming community, select a typical farm there and operate it for a few years, we are sure to get first-hand experience with some of these "limiting factors" that have been mentioned in the relationship of machinery to agriculture.

A generation or so ago it was quite easy in some parts of the country to engage in farming without cash in your pocket or in a bank. One could always rent a farm or even buy one without paying anything down. Horses, machinery and seed could be obtained by signing notes. It was about that time, nearly 35 years ago, and under those circumstances that I started farming on my own. Two years later I went broke. I did salvage an interest in a threshing machine because that had been purchased on four years' time, instead of the one or two years which were the customary terms on horses and the smaller machines. I have been farming on some scale ever since. I am not going to draw any conclusions from this experience. It is cited here merely as a chronological corollary to what I wish to bring out.

There is no question that farm machinery has been improved and made more efficient, which enables a farmer to turn out more work in a given time and with less physical effort. Also, many new farm machines which were non-existent thirty years ago have been made available to farmers, or at least were available before the war.

(Because of the many abnormalities and economic incongruities that now prevail, it is fair I think to take conditions as they were in 1940 as a reasonable normal for this discussion. If the farmer can return to that level at the end of the war, and proceed from that point, I think he will be lucky.)

The extent to which the farmer has availed himself of modern machinery is a matter of record: (1) In 1940 there were about 1,600,000 tractors in use on our farms compared with possibly 10,000 in 1910. (2) In 1910 the combine was practically unknown except for a few that were in use in one or two states on the Pacific Coast. In 1940 about 250,000 helped to harvest our crops. (3) In 1910 farmers had no trucks; in 1940 they had a million of them. (4) In 1940 they purchased nearly one-half billion dollars worth of farm equipment, not including trucks, as compared with about one-fifth of that in 1910.

In addition to machinery, there has been made available to the farmer a long list of technical developments. Agriculture has benefited by research information, education and various services that have been made available through governmental agencies and state institutions, farm organizations and individual farmers:

1 Plant breeders have given us more productive plants, improved their adaptability to soils and climate and made them more resistant or tolerant to disease and insect pests.

2 Improvements have been made in livestock by breeding, sanitation and more scientific feeding.

3 Better control of soils and fertility has been achieved by better use of cover crops, manure, lime and fertilizers, legumes, range and pasture improvements, by terracing, contour farming, strip cropping, etc.

4 Some progress has been made in processing and in finding new uses for farm products.

5 Farm cooperatives or marketing and purchasing associations have flourished and now number well over ten thousand and include in their membership about half the farmers in the country.

6 In 1940, about 70,000 people in the U. S. Department of Agriculture alone were engaged in servicing agriculture, compared with about 15,000 in 1910.

7 The Agricultural Adjustment Act became a law in 1933 and since then all sorts of economic plans and edicts have been directed at the farmer, sometimes under coercion.

Now what has been the effect of all this on the welfare or earning power of farmers? How much have all these contributions improved the efficiency index in agriculture?

Unfortunately there are very few actual records available of individual farms, extending over a period of years, which could be

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis., June, 1944.

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cited as specific answers. Besides, a survey of this sort would be difficult to make, but I think I can convince you without a survey that it is nearly as easy for a farmer to go broke now as it was 30 years ago. In lieu of such individual farm records we can resort to agricultural statistics for the whole farm enterprise in the country, which should give us some idea of the gain that has been made. So first we might take a look at the farm property statement in 1940 and compare it with the 1910 statement (Table 1).

TABLE 1. FARM PROPERTY VALUATION

	1910	1940
Real estate (land and buildings)	$34,801,000,000	$33,642,000,000
Machinery equipment*	1,380,000,000	2,633,000,000
Livestock, crops on hand	5,780,000,000	5,871,000,000
Total	$41,961,000,000	$42,146,000,000
Farm mortgage debt	3,207,000,000	6,906,000,000
Apparent net worth	$38,754,000,000	$35,240,000,000

*Includes 40 per cent of automobiles; 100 per cent of other vehicles

(It will be noted that figures for single years have been used instead of computing average values for longer periods, and they come very close to what would have been obtained by striking averages. Most of the subsequent figures will be similarly derived unless they deviate substantially from the normal.)

The statement of Uncle Sam's farming enterprise as submitted does not look so good. When we subtract the farm mortgage debt it shows a 3½ billion dollar depreciation in assets since 1910.

If some of you think that the farmer has been getting away with some money to avoid taxes or for any other reason, we can do as the Treasury Department would do and look into the records to see what has been going on and what the earnings and expenditures have been. That will be the purpose of some of the tables that follow.

TABLE 2. EXTENT OF THE FARMING ENTERPRISE

	1910	1940
Number of farms	6,361,000	6,096,000
Population on farms	32,077,000	30,546,000
Farm employment	12,146,000	10,585,000

These figures in Table 2 reflect some progress in labor efficiency. The reduction in number of farms of nearly 300,000, or 5 per cent from 1910 to 1940, meant a corresponding reduction in farm population, and probably a corresponding reduction in farm labor. However, most of these farms that have disappeared from the "farm count" were contributing very little to the agricultural production of the country, so it is difficult to tell to what extent our increased efficiency has offset the disappearance of this labor.

The changes that have taken place in total production are shown in Tables 3, 4, 5 and 6.

TABLE 3. PRODUCTION OF PRINCIPAL FEED CROPS

	1910		1940	
	Acres (000)	Production (thousand tons)	Acres (000)	Production (thousand tons)
Corn	102,267	79,878	86,738	68,897
Oats	36,844	17,696	35,393	19,936
Barley	7,546	3,418	13,496	6,442
Total	146,657	100,992	135,627	95,275

TABLE 4. PRODUCTION OF PRINCIPAL FOOD CROPS

	1910		1940	
	Acres (000)	Production (thousand bu)	Acres (000)	Production (thousand bu)
Wheat	45,793	625,476	52,980	812,374
Rye	2,262	29,098	3,210	41,149
Rice	666	24,731	1,069	54,433
Buckwheat	840	14,536	389	6,493
Potatoes (all)	4,278	402,360	3,529	431,914
Total	53,839	1,096,201	61,177	1,346,363

TABLE 5. FIBER AND FORAGE CROPS

	1910		1940	
	Acres	Production	Acres	Production
Cotton	31,508,000	11,609,000 bales	23,861,000	12,566,000 bales
Hay	68,332,000	79,998,000 tons	71,834,000	94,731,000 tons
Total	99,840,000		95,695,000	

TABLE 6. TOTAL OF 17 PRINCIPAL CROPS HARVESTED*

1910 — 305,651,000 acres
1940 — 300,451,000 "

*Corn, oats, barley, wheat, rye, buckwheat, rice, flaxseed, cotton, tame hay, wild hay, edible beans, potatoes, sweet potatoes, tobacco, sugar beets and sugar cane.

Table 7 shows about a 20 per cent increase in income, and we must bear in mind that the 1940 figure includes $766,000,000 government payments. If we also consider the lower purchasing power of the dollar in 1940, it is apparent that the farmer received actually less for his efforts in that year than he did in 1910.

TABLE 7. FARM INCOME AND EXPENSES

	1910	1940
Gross farm income	$7,352,000,000	$11,043,000,000
Total expenses of production	3,599,000,000	6,464,000,000
Net income	3,753,000,000	4,579,000,000
Inventory correction	151,000,000	96,000,000
Actual net income	$3,904,000,000	$ 4,675,000,000

These figures are self-explanatory. They are not complete and they are presented merely to summarize quickly the economic trend during the last generation in farming, and especially to serve in this discussion as an approximate measure of the production efficiency in agriculture.

There has been a substantial increase in livestock and shifts from one crop to another. On many farms the work has been made easier and drudgery has been lessened. Yet there is very little more leisure to be found on farms now than a generation ago. Working hours are just as long.

The gains that have been made should not be minimized, but when we consider what has been put into agriculture in the way of mechanical equipment, service and technical advancements, the gain has been so exceedingly and discouragingly small that I believe we should begin to look for the reasons for this failure. I think we should begin to find out why all these things that have been accomplished in the name of agricultural advancement and in the name of agricultural engineering have not contributed more to the composite results in agriculture and to the economic welfare of the farmer.

The reasons are complicated, and many of them are obviously of an economic nature. I can only hope to point out some of the most apparent ones:

First, some of this business which comes under agricultural service and improved machinery is obviously overrated and some of it, as a matter of fact, has proved impractical or of negative value when put to the test by farmers.

However, some of that is to be expected. It is perhaps the unavoidable price of progress. A far more important factor in delaying the benefits of worth-while improvements is the time lag between the introduction of a better practice or a better machine and its acceptance and widespread application among farmers. One thing that would shorten this lag, in my opinion, is better understanding and cooperation among the various departments and individuals engaged in agricultural work. This includes those on both public service and private industry payrolls.

Second, some of the agricultural problems which farmers face today, and a few of them are of growing menace, have to some extent cancelled out the inherent gains of the technological advancements and improved mechanical efficiency. In fact, new machines, more power, and new practices have had to be employed, in many cases, primarily to combat the menaces of insects, disease, weeds, soil exhaustion and erosion. Undoubtedly the most serious of these problems is soil erosion. Therefore, one of the most urgent needs of the farmer today is the acceptance and adoption of soil conservation practices.

Third, we might analyze more specifically why machinery, which has been employed on an increasing scale as shown by the records, has not been more effective in raising our over-all efficiency in farming.

As we go from one farm to another we find several and varying reasons. For one thing we find relatively few farms that are effectively mechanized, and most of them are in varying degrees and stages of mechanization. We still find hand, horse and tractor methods employed and conflicting with one another on the same farm. It is doubtful if more than one-third of our farms in the best agricultural states are making effective use of reasonably modern machinery.

The farmer usually buys his machinery one unit at a time and the transition from horse to tractor machinery and methods involves certain problems which have not been fully solved.

The next problem we get into is the variation in farm sizes, type of farming and crops grown. We may find conditions where the annual carrying cost of the machinery may run up to $10.00

per acre for common field crops that normally might not gross more than $30.00 per acre.

Here is a picture of a typical farm in Walworth County, one of the best agricultural counties in Wisconsin and one that ranks high for the entire country. It is essentially a dairy farm although some hogs and poultry help with the income. The size of the farm is 160 acres. About three-fourths of the farms in the county are smaller and the average is 126 acres.

In 1940 this farm was sold for $14,500.00, or about $90.00 per acre for the land and improvements. The purchaser, who was a farmer, had to equip the farm with machinery and livestock. Here is the list of machinery purchased and approximate prices:

General Farm Machines	
Tractor	$1250.00
Plow	160.00
Walking plow	25.00
Disk	200.00
Weeder (second hand)	120.00
Harrow	50.00
Manure spreader	200.00
Lime spreader	65.00
Soil pulverizer	125.00
	$2195.00

Corn Machinery	
Planter	130.00
Cultivator	200.00
Binder	350.00
Silo filler	320.00
Husker-shredder (s.h.)	450.00
	$1450.00

Small Grain Machinery	
Grain drill with seed and fertilizer attachments	260.00
Grain binder	270.00
	$ 530.00

Haying Machinery	
Mower (power)	130.00
Side-delivery rake	150.00
Loader	160.00
	$ 440.00

Miscellaneous	
Truck (50 per cent)	450.00
Automobile (20 per cent)	180.00
Team of horses	300.00
Wagons (two)	140.00
Fanning mill	60.00
Feed mill	150.00
	$1280.00

Summary	
General farm machines	$2195.00
Corn machinery	1450.00
Small grain machinery	530.00
Haying machinery	440.00
Miscellaneous	1280.00
Total	$5895.00

This farm has 135 acres under cultivation and the remainder is permanent pasture and farmstead. In 1940 the following crops were grown:

Corn	44 acres
Oats and barley	36 "
Soybeans	6 "
Alfalfa and other hay	22 "
Rotation pasture	23 "
Hog pasture	4 "
	135 acres

You will see that the initial investment in the mechanical equipment employed in connection with the crops is approximately $43.00 per acre on the average, including the hay and pasture acreage, and considerably more for the corn.

The experience so far with this farm shows that it can support this machinery. Where we run into trouble is on farms where the operation is limited to a small acreage of corn or some other crop that requires efficient machinery to make it available for market or feed on the farm. There is no simple solution and conditions vary from farm to farm, which complicates the problem. Some possibilities, however, may be mentioned:

1 Less diversification by eliminating some crops and growing more of others. However, that procedure invariably leads to other problems which involve rotation, soil conservation, effective use of labor and others, which are too variable to discuss here.

2 Work toward simpler cultural practices which may involve new crops, and here is where agronomists and geneticists may have to come to the rescue of the farmer. For example, you can see what it would mean to the marginal corn producer if plant breeders could supply him with a variety of corn that could be planted and harvested with ordinary small grain machinery, and would yield about the same feed units per acre as our present varieties do in those localities. The scientist might have to go back to some primitive strain and from it develop a plant with a smaller stalk and a smaller ear, but with many more stalks possible per acre.

3 Perhaps we should encourage more custom work or sharing of machinery with neighbors. The report on rental rates for machinery presented to the American Society of Agricultural Engineers some time ago was a step in that direction. There is considerable custom, rental and exchange work going on now among farmers, and I believe there is need of more recognition of these practices and their possibilities.

4 It is obvious that important improvements have been made in farm machinery with respect to adaptability and mechanical efficiency and continued progress along this line is bound to react to the benefit of farmers. There has been a trend toward smaller units in many machines and this trend seems to be accelerating.

It is important, however, that we consider the adaptability of machines from every angle — particularly their relationship to the economical operation of the farm or, to put it more bluntly, the ability of the machine to put money into the farmer's pocket.

This is the criterion that counts. The salability of a machine over a brief period of time may give a misleading impression as to the success of a machine in this respect.

There is some danger in my opinion that the trend with respect to small sizes may go too far. Too much emphasis on smallness with correspondingly low prices may mislead us and result in an economic boomerang for the farmer.

Perhaps a simple illustration will help to explain this possibility. Let us assume that a farmer is deciding between two tractors of the same quality, except for size. Tractor A costs $666 and Tractor B costs $1000 and has about 50 per cent more capacity, which may be utilized either for pulling a wider implement or traveling at a higher speed. (Of course there is no reason why the price spread should be as wide as the spread in power.) The cost of a tractor operator in normal times is about $3.50 per day with board and room, but we will use a $3.00 per day rate to simplify our figuring. Let us assume 1,000 days as the life of these tractors. When Tractor A is worn out, the farmer will have saved enough in labor with Tractor B to purchase a new tractor, and he will still have three years of work left in the larger tractor. The same thing applies to a combine.

In this illustration we have taken account of only the cost of the tractor and the man on it. The investment in some of the implements used with the larger tractor would be higher, which would reduce the ratio of savings to some extent. On the other hand, no account has been taken of possible savings in the labor of extra men that might be involved. But if we add up all the labor saved, we haven't touched upon one big advantage which the added capacity is absolutely certain to give the farmer.

The two principal factors which determine the cost per unit of producing a crop are (1) *yields* and (2) *effective use of labor.* This is a point I want to emphasize: There is nothing within the farmer's control that has more to do with high yields and certainty of crops than good seedbed preparation and timeliness. To accomplish these, ample power and machine capacity are essential. You understand this as well as I, and I need only point out the experience many farmers had this spring and have every spring to show why so much depends on planting a crop at the right time and immediately after the seedbed has been put in good shape.

When the continuity of these operations is broken by bad weather, the farmer has to prepare the seedbed again by disking and harrowing or tilling, or the seed goes in when the ground is in poor condition for planting. Under these conditions ample mechanical capacity will put money into the farmer's pocket far beyond the savings in labor.

I hope that these comments on machine efficiency will not be misconstrued. I am not opposing small tractors or machinery for farms for which they are fitted. I merely want to emphasize the importance in farming of having power and machinery that is adapted economically and agriculturally to the work on the farm. Over twenty-five years ago I was responsible for an extensive survey of power requirements on farms, by types and size groups, and later a part of the report was published in "Automotive Industries" for July 6, 1922. That survey disclosed the widespread need for general-purpose tractors and other types of small tractors, and neither the underlying conditions nor my conclusions have changed materially since then.

Fourth, and finally, there perhaps should be mentioned one other reason — and this has been touched upon before — for the disparity between what the farmer gets out of farming and what is going into it in the way of mechanical and technical improvements. It seems there is need of more coordination and cooperation between the activities and efforts of the many specialists who are now serving agriculture. Perhaps we need fewer specialists and more country doctors.

It seems to me that if engineers become better acquainted with soil experts, agronomists, plant breeders, animal husbandmen, farm management men, practical farmers, etc., and vice versa, it would react to the practical benefit of the farmer. Particularly would it be helpful for those agricultural engi- *(Continued on page 374)*

Planning Farm Ponds to Insure Ample Water Supply

By D. B. Krimgold and L. L. Harrold

MEMBER A.S.A.E.

THE subject of farm and ranch ponds has been previously discussed before this group. Howard Matson in his article in AGRICULTURAL ENGINEERING for November, 1943 (page 380), estimated that in 1943 there were probably more than a million farm and ranch ponds; he stated that many additional ponds are needed and that a great deal of work must be done in improving existing ponds. This opinion is amply substantiated by the estimates contained in the preliminary state postwar planning reports.

Twelve of the reports examined by the senior author, including those of Colorado, Georgia, Idaho, Montana, Pennsylvania, South Dakota, Tennessee, Texas, Vermont, Virginia, Washington, and West Virginia, call for a total of some 250,000 impounding reservoirs needed for a sound agricultural program. The Missouri report calls for 500,000 ponds for that state alone. The fact that of the above 250,000 the report of the state of Georgia calls for some 34,000 farm ponds should dispel the erroneous idea some people may still have that the need for impounding reservoirs on ranches and farms is limited to the arid and semiarid parts of the country. It may also be well to point out that the uses of farm ponds are not necessarily limited to supplying water for livestock, for domestic use, and for supplementary irrigation. To these should be added the propagation of fish; water supply for spraying orchards, for fire protection, and for ice on the farm; and various recreational uses such as fishing, boating, and ice skating. These are not merely rationalizations; they are now actually found in many places. Another important and logical use of farm ponds is for disposal of excess water from terraced fields and diversion ditches.

There has been some talk recently on the use of farm ponds as a flood control measure, the implication being that with a sufficient number of ponds on a watershed enough water can be stored and retarded by temporary spillway storage to reduce the magnitude of floods. Whether this is sound, especially on major watersheds, remains to be shown by careful analysis of all the factors involved. It appears more than likely that the use of impounding reservoirs on farms and ranches will be greatly expanded. The farm planner and agricultural engineer will be called upon to plan and construct such reservoirs under various conditions and for multiple purposes.

The purpose of the reservoir, the topographic and geologic characteristics of the site, and hydrologic factors, as well as economic and legal factors and health hazards, all enter into the proper planning of an adequate impounding reservoir on a ranch or farm. The hydrologic considerations involved are basic and common to all uses and conditions. It is the purpose of this paper to share some of the information and thoughts on the subject and to discuss the hydrologic factors involved, to demonstrate the interrelationship between such factors as the size of drainage area and the dimensions of reservoirs, and to illustrate the application of these relationships in the proper design of small impounding reservoirs.

This paper is not intended to offer a complete and rigorous treatment of all the hydrologic factors. A good deal more work and basic data will be required before this can be done. It is felt, however, that with certain reasonable assumptions the limited information now available can be utilized in arriving at adequate procedures and values to be used in the planning and design.

For small, relatively shallow reservoirs for a given period of time and for each increment in depth for which the surface area of the pond is practically constant, the relationship between the various hydrologic factors and the dimensions of the reservoir can be expressed as follows:

$$\frac{RA}{a} + P - \left(E + \frac{u}{a} + S\right) = d + \frac{W}{a}$$

where A (acres) = the size of the drainage area

R (acre-feet) = total runoff from the contributing drainage area per acre during the period under consideration

a (acres) = mean surface area of the reservoir for a given increment in depth

P (feet) = precipitation falling on the reservoir during the period, irrespective of whether or not it produces surface runoff from the drainage area

E (feet) = evaporation from the surface of the reservoir during the period under consideration

u (acre-feet) = amount of water used by livestock or otherwise during the period under consideration

S (feet) = seepage during the period

d (feet) = increase (+) or decrease (−) in the depth interval

W (acre-feet) = amount of water in acre-feet in excess of the capacity of the reservoir which is wasted over the spillway.

Another factor, not included in the above expression, is the loss of reservoir capacity due to silting, which must be considered especially when the drainage area is cultivated.

Of the factors listed above, precipitation is entirely beyond control. Evaporation is practically so, although some means are available to reduce evaporation which might be considered under special conditions. Runoff per unit area, being a function of precipitation, is largely beyond control except by modification of vegetal cover and tillage practices on the contributing drainage area. The required amount of water for use may be fixed, or an adjustment can be made to conform to the available net supply. The size of the drainage area may be fixed by the characteristics of the site or may be increased or decreased by diversion. Seepage may in many places determine the feasibility of the site. Its extent must be determined in each case and provisions made for reducing it or eliminating it entirely. Silting will depend on the vegetal cover and tillage practices on the drainage area; it can, in most areas, be effectively controlled even from cultivated land by means of vegetation in the channels and on the land immediately adjoining the reservoir.

In the following discussion it will be assumed that seepage is largely eliminated by treating the reservoir site where practicable or by avoiding sites where treatment is not practicable. If seepage is eliminated and adequate provisions are made to eliminate silting, the general expression of the relationships between the various factors entering into the design of small impounding reservoirs becomes

$$\frac{RA}{a} + P - E - \frac{u}{a} = d + \frac{W}{a} \qquad [1]$$

While spillway storage may, under certain conditions, be a factor in abating floods, the primary consideration in a pond designed to furnish required amounts of usable water on a farm or ranch is the dependability of the water supply. What constitutes a "dependable supply" (or stated in other words, how often can the amount of usable water or the depth of water in the reservoir be allowed to fall below the required minimum?) will depend on the purpose of the reservoir and on economic value of water. In one locality a supply that will not fail more often than once in 25 years may

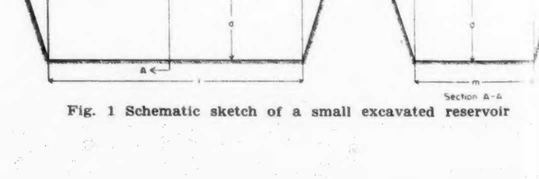


Fig. 1 Schematic sketch of a small excavated reservoir

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis., June, 1944, as a contribution of the Soil and Water Division.

D. B. KRIMGOLD and L. L. HARROLD are, respectively, soil conservationist, runoff studies, and project supervisor, North Appalachian Experimental Watershed, Soil Conservation Service, U. S. Department of Agriculture.

constitute a dependable supply for a given purpose, whereas in another a failure of once in 10 or even 5 years may be tolerated.

It is readily apparent that the problem involves the determination of the amounts of rainfall, runoff, and evaporation that may be expected to be equalled or exceeded at various recurrence intervals in the future. This fact limits the accuracy with which other factors need be determined. It does not, however, permit making assumptions which are unwarranted and in many cases unnecessary.

In view of uncertainties involved in the determination of R, P, and E for various recurrence intervals, it is not necessary to divide the total depth of a reservoir into increments for which the surface area is practically constant. If the mean surface area of a reservoir with reasonably uniform banks is properly determined, the error introduced by applying it to the entire depth will probably be consistent with the uncertainties mentioned. In an excavated reservoir, the mean surface area a for any depth of water d can be expressed thus

$$a = \frac{a_0 + (a_0 + bd + cd^2)}{2}$$

$$= a_0 + \tfrac{1}{2}\,(bd + cd^2)$$

where a_0 is the surface when d equals zero and b and c are constants determined by the length and width of a_0 and the side slopes of the reservoir. For a reservoir with dimensions shown in Fig. 1,

$$a_0 = lm$$

and the expression for the mean surface area would be

$$a = lm + (mz + lz)d + (2z^2)d^2$$

For a small reservoir with $l = 50$ ft, $m = 80$ ft, $d = 10$ ft, and $z = 2$, this expression reduces to

$$a = 4000 + 130 \times 2 \times 10 + 2\,(20)^2 = 7400 \text{ sq ft, or } 0.17 \text{ acres.}$$

It can readily be seen from the above example that when z and d are large in relation to a_0 the assumption of a constant surface area throughout the depth of even an excavated reservoir is entirely unwarranted. Although the excavated reservoirs will, in most cases, prove hydrologically more efficient, by far the majority of reservoirs will be those created by dams across natural depressions or watercourses. The mean surface areas of such reservoirs can be obtained from the depth-area-volume curves of the reservoir or can be computed from the prismoidal formula

$$\frac{1}{6}\;(B + T + 4M)$$

where B is the area at or near the bottom, T the area at spillway elevation, and M the area at middepth. Measurements of the three areas can be obtained with sufficient accuracy by running several lines of levels (hand level will suffice for small ponds) across the reservoir site and planimetering the areas within contour lines drawn through the proper elevations.

Having made the several assumptions and realizing the limitations, we can now consider expression [1] in which a is the mean surface area determined as suggested above.

In application of the relationship $RA/a + P - E - u/a = d + W/a$ in design, it is necessary first to determine expectancies of rainfall, runoff per unit area, and evaporation. This must be done on a seasonal rather than annual basis. In many localities only two seasons, winter and summer, may have to be considered, while in others, such as the Blacklands of Texas, three seasons may have to be used. The number of seasons into which the year must be divided and the months to be included in each season are determined by the distribution of rainfall; by runoff, evaporation, transpiration, soil moisture; and by cover and tillage conditions. Furthermore, it is not sufficient to determine expectancies for each season; this must be done for critical periods consisting of two, three, and more consecutive seasons. The combination of rainfall, runoff, and evaporation may be such that a failure would be indicated if values for three or more consecutive seasons are considered, but not for one or two seasons.

Long-time records of runoff from small drainage areas are practically non-existent. It is therefore necessary to convert available records of rainfall into runoff by means of conversion curves derived from short-time runoff and corresponding rainfall records.

The foregoing discussion indicates that the determination of expectancies of rainfall, runoff, and evaporation is a job for the qualified hydrologist who has access to the necessary basic data and is capable of interpreting them properly. The engineer or farm planner, unless they be expert hydrologists as well, will have neither the time nor the facilities to handle this phase of the problem. They will, therefore, prefer to look to the hydrologists for this type of information for the locality in which the reservoir or reservoirs are to be planned. The engineer and farm planner should, however, have an understanding of the principles involved if they are to utilize intelligently information made available to them in the form of charts or tables. With this in view, and keeping in mind the various assumptions and their limitations, the following relationships implied in $RA/a + P - E - u/a = d + W/a$ are pointed out:

1 When it is desired to prevent excessive waste over the spillways of small reservoirs, which is detrimental to the vegetative linings commonly used, the size of the drainage area should not exceed that required to fill the reservoir within a reasonable time of completion and to produce a sufficient water supply during critical periods.

2 For a given mean surface area of reservoir, greater depth will provide more storage and less water will be wasted over the spillway. When runoff and rainfall are less than evaporation losses plus water utilized during a given period, there will be no waste and during droughts the storage in a deep reservoir will supply water for longer periods than a shallower reservoir.

3 Evaporation expressed in feet is independent of the area and depth in small, relatively shallow reservoirs.

4 The increase in depth of water due to a given amount of precipitation falling on the reservoir is independent of the mean surface area or depth of the reservoir.

5 The increase in depth of water due to a given amount of runoff varies inversely with the area of the reservoir; the greater the area, the smaller the increase in depth produced by a given amount of runoff.

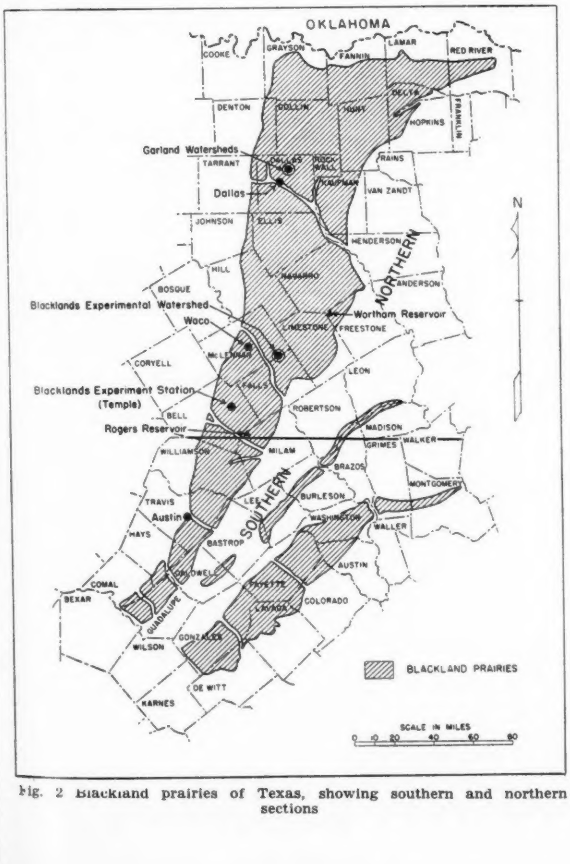


Fig. 2 Blackland prairies of Texas, showing southern and northern sections

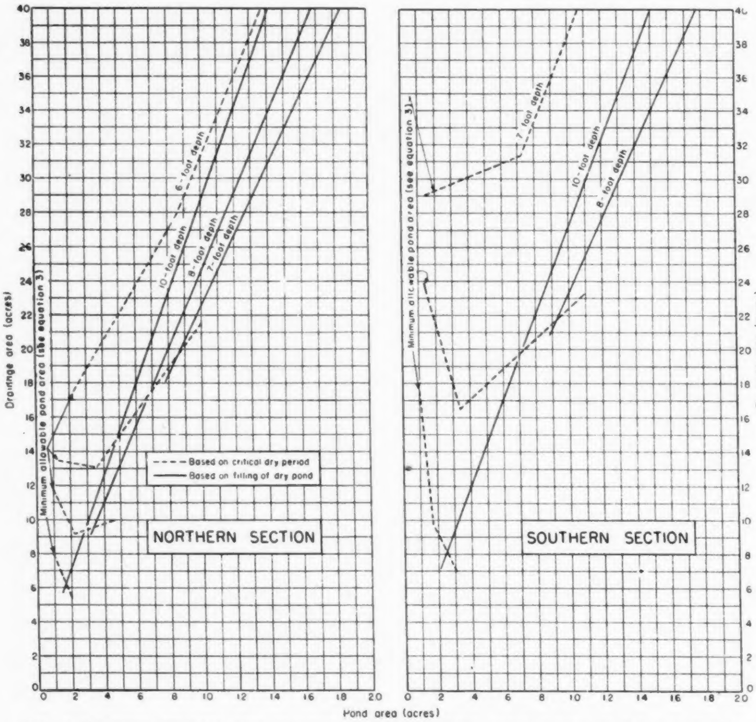


Fig. 3 Minimum drainage area required for a dependable water supply of 0.5 acre-foot per year in the Blacklands of Texas

6 The decrease in depth due to a given use will vary inversely with the surface area of the reservoir.

7 To provide a dependable supply in a small reservoir, the depth of usable water can at no time be less than the difference between the total demand and the total supply during the critical period. This condition can be expressed as follows:

$$d \geqq \left(E+\frac{u}{a}\right)-\left(\frac{RA}{a}+P\right) \qquad [2]$$

8 For critical periods when no runoff can be expected, the minimum allowable mean surface area of a reservoir with a given depth is expressed as follows:

$$a \geqq \frac{u}{P+d-E} \qquad [3]$$

9 The minimum drainage area required to fill a reservoir with a given depth d and a corresponding mean surface area a within a reasonable time after completion (1 or 2 years) is expressed as follows:

$$A=\left(d-P+E+\frac{u}{a}\right)\frac{a}{R} \qquad [4]$$

where P, E, and R are amounts for the reasonable period (1 or 2 years) that can be expected to be equalled or exceeded 50 or 75 per cent of the time.

10 The minimum drainage area required to maintain a dependable supply in a reservoir with a depth d and a corresponding mean surface area a after the reservoir was once filled is expressed as follows:

$$A=\left(E+\frac{u}{a}-P-d\right)\frac{a}{R} \qquad [5]$$

With these relationships, curves or tables can be prepared for a given hydrologic region showing the minimum drainage areas needed to fill and maintain required supplies of water in reservoirs with various depths and corresponding mean surface areas. For the purpose of this paper a hydrologic region is one within which expectancies of rainfall, runoff, and evaporation do not vary widely. Such curves for the Blacklands of Texas, based on rainfall, runoff, and other hydrologic data obtained by the Soil Conservation Service, were included in a recent technical publication of the Service, entitled "Preliminary Report on Watershed Studies near Waco and Garland, Texas," SCS-TP-53 (processed), by L. L. Harrold, D. B. Krimgold, and L. A. Westby.

Figs. 2 and 3, adapted from this publication, will illustrate the type of information that can be made available. Fig. 2 shows the division of the Blacklands into southern and northern sections which in this case was governed largely by rainfall and runoff expectancies.

Fig. 3 is one of two sets of design curves for small excavated reservoirs in the Blacklands of Texas included in the publication, which also contains examples illustrating the use of such curves in design and the use of amounts of evaporation, rainfall, and runoff (determined for the proper expectancies) in the solution of cases not covered by the design curves.

With the records of runoff from small drainage areas and other data obtained by the Soil Conservation Service within the last decade, information similar to that prepared for the Blacklands of Texas is being developed for other hydrologic regions. The curves and information cited are by no means the complete solution of even the hydrologic phases of the problem. Much can and should be done to utilize available data more fully and to develop improved methods of analysis whereby the information made available for design will be subject to fewer assumptions and will cover adequately additional phases of the problem, such as the question of spillway storage, which has important economic implications. Two technical publications containing information on the hydrologic design of small reservoirs are now being prepared by the Soil Conservation Service. These reports will embody improvements in analysis and procedure being made as the work progresses.

Other phases of the problem, such as disposal of excess water and of silt reaching the reservoir, adequate methods of mosquito control on small reservoirs, and proper methods of construction, must be given ample thought and consideration.

The small impounding reservoir on the ranch and the farm has an important place in a well-rounded, sound agricultural program. It merits all the attention and thought the hydrologist, engineer, and farm planner can give it.

Farming Efficiency

(Continued from page 371)

neers possessed with the diabolical urge to drain every marsh and pond, and to ditch every swale, to get better acquainted with biologists and wild life specialists. It might help to curb certain other fetishes and fads. Take for example the extremists on land utilization and cranks on mechanical efficiency who would eliminate every patch of shrub and wood and utilize every fence row. This has gone on apparently without any thought about the effects on bird life, or on insects that serve as pollinators, or on wind and water erosion and so on. Efficiency in agriculture will not be enhanced by ruthless use of horsepower and steel.

Obviously I am not offering a prescription for bigger dividends to farmers, but I do hope I have emphasized some of the symptoms and pointed out some of the causes why the effects of modern machinery and advanced practices have not shown up more favorably in the farm ledger. I believe that the profession of agricultural engineering is the logical agency for correcting some of the conditions mentioned and particularly for correlating the attack on them by our allies in other phases of agriculture.

Trends in Structures for Hay and Bedding Storage

By S. A. Witzel
MEMBER A.S.A.E.

AGRICULTURAL engineers throughout the country are at work investigating and improving what is coming to be known as "forage", an old term with a new meaning. Through work and sweat and use the engineer has given it not only new meaning and new values, but its challenge will lead him tirelessly on until he becomes its master. Some progress has been made and the fruits of engineering have already been sampled by enough American farmers so that the demand for equipment, structures, and aid in planning for their use has been spontaneous and unrelenting.

In attempting to approach the subject as indicated by the title of this paper, the author found himself in a field that could not be easily divided. The difficulty was that it had more acres than the blueprint called for. Therefore, following the engineer's prescribed practice for highest efficiency, we will simply throw in our disk, put seed and fertilizer in the drill, adjust the harrow, and, starting around the outside, keep going until we wind up in the center. It is hoped that this won't detract from the benefits nor reduce the yield.

The harvesting and storage of bedding and forage is the field, and it all belongs together as a unit if we are to study trends. Is not the starting point of forage the plant, and is not the end point of forage the animal? Technology is leading the way for better plants and more of them. Technology is leading the way in the improvement of dairy animals and their efficiency in production. When the efficient green plant is grazed by the efficient dairy animal at the proper season, production and milk quality reach a new high with the cost of production at rock bottom. Forage in its prime doesn't last all summer and a forage crop at its prime will outproduce the capacity of the animals to eat it. The surplus is a reserve for the time when the forage plant growing season has ended.

The limits of our field now can be distinctly seen. It covers the harvesting and storage of all forage, but let us inspect it more carefully. If I can read the signs correctly, engineers with the aid of their fellow technologists have taken upon themselves the task of providing "prime forage" for efficient, comfortably housed animals in all seasons; prime forage without loss of nutrient, vitamin or palatability; prime forage which insures the maximum production from the land; prime forage and more prime forage for profit, conservation and a sound future for agriculture.

Bedding is an important and very essential requirement of the livestock farm. For sanitation, animal comfort and soil-building properties it is just as much a part of the livestock farm as the livestock itself. However, it is an appendage to our subject of forage, so its inclusion is mainly for convenience and expediency, since machinery and storage for forage will have their effect on it.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis., June, 1944, as a contribution of the Farm Structures Division.

S. A. WITZEL is associate professor of agricultural engineering, University of Wisconsin.

Fundamental Methods. One has only to read the more recent files of AGRICULTURAL ENGINEERING to appraise the rapid and broad development being made in the study of forage — the machines, the processes, and the storage structures that have been developed all with the aim of producing prime forage. Various methods have been developed, and while there is no one best method, there will be a best combination of methods for every farm. While new methods may be developed by present and pending research, the encouraging fact is that a number of methods are being perfected in competition with each other, tending to force the fullest possible development of each quickly and efficiently.

The fundamental methods of forage production, after it has been grown, may be listed as follows:

1 Loose forage, field cured
2 Loose forage, barn cured
3 Chopped forage, field cured
4 Chopped forage, barn cured
5 Baled forage, field cured
6 Forage ensiling
7 Artificially dried forage
8 Bedding (straw, shredded or chopped corn stalks, etc., but not forage, strictly speaking).

Some of these methods are now known to be more effective than others in the production of prime forage for year-round use. Others are promising, but need further development. The search for still other new methods needs to be relentlessly pursued. In like manner, if judged by labor and power standards, some methods are far superior to others. Machines recently perfected need only to be made available to the farmer for their wide acceptance.

Equipment and Machinery. Trends in structures for the storage of forage have in the past been largely limited by the requirements of loose hay storage. Trends in the future design of storage structures will be in large part influenced by the requirements of prime forage production, equipment, machinery available and in the labor savings made possible by adjustments in design. Economy in design will have to reckon with capitalized labor costs in addition to the usual annual building cost charges.

The new machines in the forage harvesting field include among others:

1 The forage harvester for dry forage, green forage and bedding. This machine cuts or picks up, chops and loads any forage crop when equipped with the proper attachments.

2 Forage blower or elevator for use in conjunction with the forage harvester for placing the forage in silo or barn.

3 The field hay baler for baling dry, field-cured forage. It picks up the dry forage and bales and loads the bales on a trailing wagon.

4 Baled-hay elevator for placing the bales in storage.

5 Molasses pump and miscellaneous equipment for applying the preservative to grass silage.

THESE TWO VIEWS SHOW STEPS IN THE EVOLUTION OF HAY STORAGE.
(Left) The roofs can be raised or lowered to provide protection from the weather. The hay is moved by hand from wagon to stack • (Right) A hay carrier is used in this shed type structure to save hand labor in storing the hay crop


(Left) The one and one-half story barn and silos on the Kath farm at Reeseville, Wis. • Hay is stored (for cattle) in circular, ventilated structures on the Jefferson County (Wis.) Farm

6 Blower and duct system for curing chopped or loose forage in the mow with natural air.

7 Artificial driers widely used for the production of highly nutritious protein roughages for mixed feeds.

8 The mechanical buck rake.

While these machines are not now available in large numbers, some are being produced. Farmers are building their own and custom work is being done so all farmers are becoming acquainted with the machines and the forage their methods produce. Farmers are also producing all types of forage with their existing equipment for the purpose of producing better roughage and in an effort to save labor.

Storage Structures. One might almost state that storage structures are frozen for the duration. It is even difficult to adjust existing structures, although a limited number were constructed before wartime building became next to impossible. Experiences with these structures and experiences with conventional storages provide a background for design. Research is urgently needed to fill in the gaps and to test and improve further what has already been done.

Trends and recent developments which have taken place in storage structures include:

1 Fireproof, insulated hay loft floors
2 Fireproof and firesafe dairy barn construction
3 One-story barns with separate ground-level storage for dry forage and provisions for moving feed horizontally on large rubber-tired carts
4 Grass silage silos
5 Ventilated storage units and ventilated bins
6 Baled-hay storages
7 Glued, laminated rafter for hay loft construction
8 Insulated and ventilated barns for ideal temperature and humidity control to insure greatest possible benefits from "prime forage"
9 Development of pen barn for animal comfort and again for greatest possible benefits from prime forage
10 Arrangement, equipment, and design for the production of higher quality milk.

Combinations of Methods. Due to the need for variety to secure maximum consumption of forage, various combinations of dry forage, corn silage and grass silage can be used. Perhaps the ideal combination is that fed by Schroeders near West Bend, Wisconsin, where approximately one-third of the dry matter is fed as corn silage, another third as grass silage and the remaining third as field-cured dry hay.

Farmers using the following methods of curing and storing forage are enthusiastic about their results:

1 Schroeders at West Bend. Sell bottled milk. Feed grass silage, corn silage and field-cured long hay. They have 3 silos and a large hay loft barn with a one-story extension.

2 Kohlers at Kohler. Sell whole milk. Put up long chopped alfalfa in 3-ft ventilated bins and get bright green forage through natural ventilation.

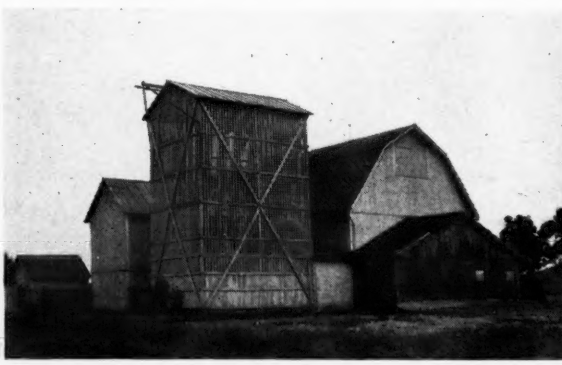
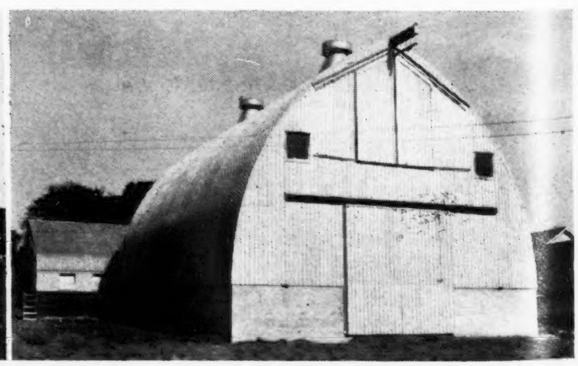
3 Edward Kummrow, Oconomowoc. Built one of first ventilated hay storage bins for long hay and straw. Started using chopped hay 4 years ago. Began using field baler to save labor last year because a field chopper was not available. Has five rubber-tired wagons and baled-hay elevator. He will put up 75 acres of alfalfa this year. Grass silage with ground corn and cob meal preservative are a part of his forage program.

4 Larry Henning, Oconomowoc. Chopped and ground corn silage, field-baled alfalfa, and is equipped for chopped grass silage. Has drive-in barn loft with insulated, fireproof floor.

5 Edward Kath and Son of Reeseville have a forage harvester on order, although they will use their silo filler if necessary to fill a silo with grass silage and fill their barn. They have 75 acres of heavy tame hay to put up and they save feeding time with chopped hay. They want another silo. The one and a half story addition to their barn was planned on a functional basis.

6 Charmany Farms at Madison have a fireproof barn constructed after a large barn fire. Here only corn and grass silage have been fed for a number of years. The farm manager still wishes he had a hay barn for bedding storage. High-quality milk is produced and sold through a Madison dairy.

7 W. W. Evans farm near Fall River. Here the dairy herd is separated from the young stock and dry (Continued on page 378)

(Left) This shows one of the first ventilated hay storage bins built by Edward Kummrow of Oconomowoc • (Right) Hay is stored loose for horses in this barn on the Jefferson County Farm

Performance of a Well-Type Domestic Freezer

By John E. Nicholas

MEMBER A.S.A.E.

THE TWO general types of domestic freezers are the "well" type with a top opening and the "reach-in" type with a side opening. Each of these types claims certain distinct advantages over the other, but both offer the same objective, that of freezing and storing foods at low temperatures.

This discussion deals primarily with a well-type experimental unit consisting of a 5-cu ft freezing and a 10-cu ft storage compartment, with a total capacity of 15 cu ft. The evaporating coil makes contact first with the four walls and bottom of the freezing compartment and then the four walls and bottom of the storage compartment. The complete unit was powered with a $\frac{1}{3}$-hp motor.

Freezer Plate and Air Temperatures. The operation of a domestic freezer is automatically controlled by a thermostat with a sensitive bulb located either in the storage or freezer compartment. If the freezing is done on the plate, packaged food is generally frozen without air motion by being placed on the bottom of the freezing compartment. The "bottom" of the freezer compartment is considered here as the "freezer plate." In its automatic operation there is an "off" and "on" phase in each cycle which permit variations in the temperature of the freezer plate and consequently of the air in the freezer and storage compartments.

To utilize the freezing and storage spaces efficiently, it is desirable to design the compartments so that there is a minimum of temperature difference in both horizontal and vertical directions, in order to maintain frozen packages at a very nearly constant temperature.

In order to demonstrate temperature variations on the vertical geometric center of the freezer compartment, air temperatures were taken at three 5-in intervals measured from the surface of the plate. Fig. 1 shows the plate and three air temperatures taken during two complete cycles. Curve 11 shows the plate temperatures, while curves 12, 13, and 14 show air temperatures at distances of 15, 10, and 5 in above the plate. Thermocouple readings were recorded every minute. The maximum temperature attained by the air was approximately −2.6 F, while that of the plate was −3.8 F. The lowest temperatures of these two points were −11.8 and −9.1 F respectively. Neither the "on" phases nor the "off" phases of the cycles were of equal duration. A short "on" interval provides a slightly higher temperature than a longer one, and similarly a long "off" interval permits a higher air and plate temperature than a short one, as is illustrated in Fig. 1.

Orienting the Zone of Zero Degrees. Since the depth of the freezer cabinet was 24 in and Fig. 1 shows that the air temperature 9 in below the lid attained a maximum of 3.6 F below zero at the "on" part of the cycle, an attempt was made to determine the location of the zone of average zero degrees. A point 2 in below the lid was chosen as the next position. Fig. 2 therefore illustrates the temperature of the air 2 in below the lid as shown by thermocouple 12, while thermocouple 11 shows the plate temperature during $1\frac{1}{2}$ cycles. It will be observed that the average air temperature 2 in below the lid was slightly below +10 F, a maximum of +11.4 F being attained when the corresponding maximum plate temperature was −2.85 F. The minimum plate and air temperatures at the end of an operating cycle were −12.8 and +7.9 F respectively. The slight lag of air temperature variations indicate that maximum and minimum values are attained a few minutes later than corresponding plate temperatures. In this test the maximum difference between the plate and the air temperatures 2 in below the lid was found to be 14.3 F at the beginning and 20.7 F at the end of the operating cycle.

The Zero Degree Zone. To attain the average zero degree zone, the third attempt shows the results in Fig. 3 when the four points measured in the freezing compartment were located 16, 18, and 20 in above the plate. Thermocouple 11 measured the plate temperature and thermocouple 12, now located 4 in below the lid and thermocouples 13 and 14 at points 2 in lower, measured air temperatures. There are two and one-half complete cycles. Fig. 3 illustrates again that under thermostatic control no two cycles in sequence were of equal duration. Temperature recorded by thermocouple 12 was now at an average value of zero degrees, varying between a maximum of +2.6 F and a minimum of −2.6 F, resulting in the average of zero degrees in that zone. Assuming that a maximum average temperature of zero degrees is needed, this indicates that if food were stored in the freezer compartment it could be safely and satisfactorily stored to within 4 in of the lid.

Freezing of Poultry Meat. To furnish some reasonable guidance on the correct method of loading the freezer plate, an attempt was also made to illustrate graphically what "should not" be done. Fig. 4 illustrates the time required to freeze cartons of cut-up, packaged poultry. (All the packages of poultry meat used in these experiments were supplied and prepared for freezing by Professor P. H. Margolf of the department of poultry husbandry.) Each package measured $2\frac{1}{4}$x6x$7\frac{1}{2}$ in. The carton was made of a thick, moistureproof paper with a top opening. A piece of cellophane placed on the top of the filled carton sealed the opening and made an exceedingly attractive frozen package of poultry meat. The upper right-hand corner of Fig. 4 shows packages A, B, and C piled on top of each other. Package E is placed adjacent to these. Numbers 11, 12, and 13 indicate the approximate locations of the thermocouples within the center of packages A, B, and C, respectively, while thermocouple 14 is placed in package E. The average weight per package was 3.68 lb. The figure shows the time required to freeze these four packages. Curve 14 indicates that package E required nearly 2 hr to precool for freezing and 6 hr to pass through the zone of crystal formation, attaining a temperature of zero degrees in about 10 hr and 40 min. The bottom package (A) attained a temperature of thirty degrees in about

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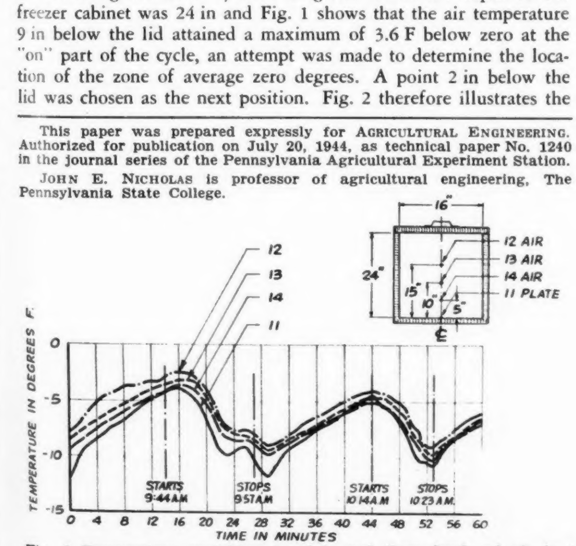


Fig. 1 Temperature variations in plate and three levels of air in a domestic freezer during cycling

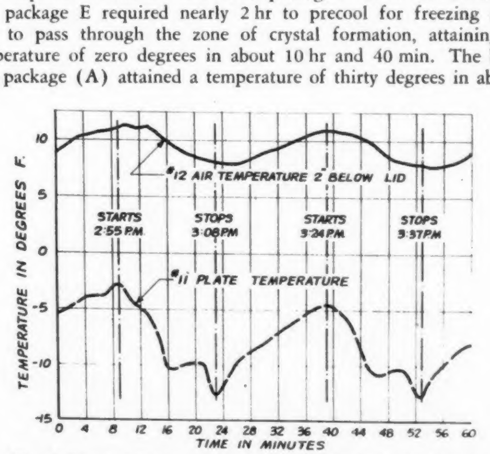


Fig. 2 Temperature variation in plate and air in the freezer compartment two inches below the lid

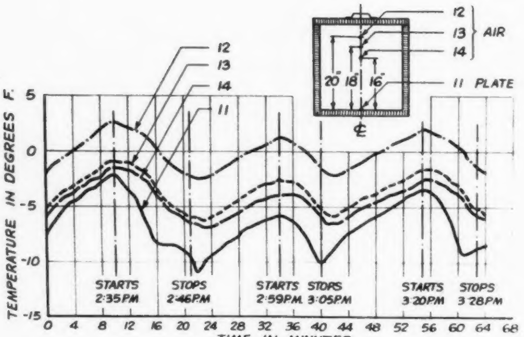


Fig. 3 Temperature variation in plate and three points of air located at 16, 18, and 20 in on the geometric vertical center line in the freezer compartment

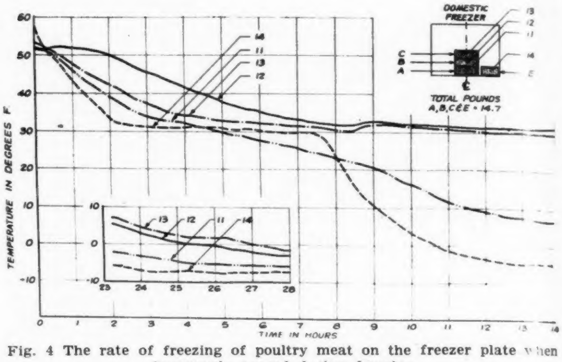


Fig. 4 The rate of freezing of poultry meat on the freezer plate when improperly spaced during freezing

five hours freezing without a definite zone of crystal formation, and zero degrees in about 22 hr, while B and C remained above freezing temperature for over 14 hr, attaining zero degress in 25½ and 27 hr, respectively. Subsequent experimental evidence showed that the same number of packages with a similar load have attained the same rate of freezing as package E when these were not piled, but placed separately on the freezer plate, thus the purpose of rapid freezing is nullified with improper placing of packages.

SUMMARY

1 This paper reports some of the experimental evidence resulting from a study of domestic type freezers.

2 It has been found that the cycles of operation are not uniform and the temperature of the air within the freezing compartment follows that of the plate.

3 Maximum and minimum plate and air temperatures attained during a cycle depend upon the length of the cycle.

4 Maximum variation between plate and air temperatures 2 in below the lid in this type of freezer studied was found to be between 14.25 and 20.7 F.

5 The zone of zero degrees average value is at a point approximately 20 in above the plate or 4 in below the lid in a freezing compartment having 24-in depth.

6 When freezing is carried out with improper placing of packages, as, for example, piling them on top of each other, fast freezing is impossible.

Trends in Structures

(Continued from page 376)

cows. The forage fed is silage, both corn and grass with preservative, and dry chopped hay stored in a ventilated hay storage structure. The young stock and dry cows get dry hay and silage. They are separated for sanitary reasons and for a greater degree of safety from the income-producing dairy cows in case of fire.

8 The Jefferson County Farm cow barn. Houses nothing but dairy cows. Hay is stored in circular, ventilated storage structures, chopped and baled.

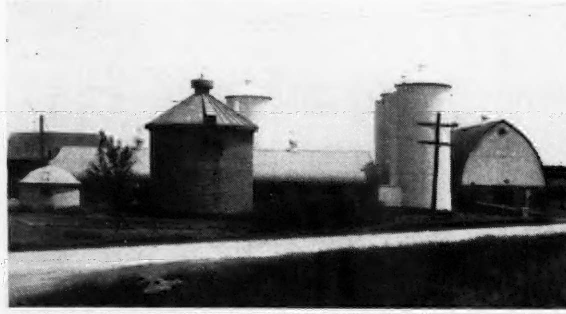
The Jefferson County Farm horse barn. Hay is stored loose for horses to get away from danger of dust. Horses can utilize a more mature forage and there is no difficulty in field drying this forage with low moisture content at the time of cutting.

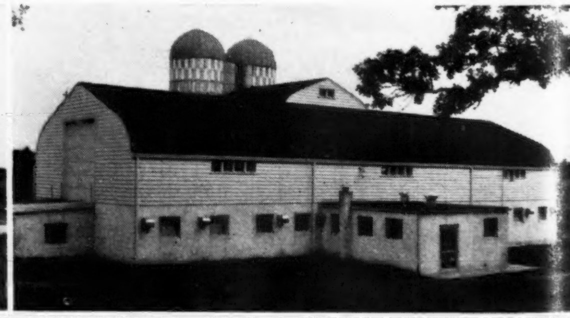
9 Dane County Farm dairy barn. This one-story masonry barn now under construction for 70 cows and young calves will supply the asylum and home for the aged with dairy products. It will have a silo for grass silage, a silo for corn silage and 50 ft to the rear, but parallel with the main barn a hay barn is being constructed. This hay barn 36x140 ft has 12-ft vertical sides and glued rafters. Storage is designed for any method of forage production they may care to use.

10 Mow drier at Wisconsin Dairy Research Barn. Chopped dry field-cured hay stored in a ventilated structure; baled, field-cured hay; grass silage; corn silage; and now chopped hay, mow cured will all be in use this season. A forage harvester is being used. A pilot bin of cured chopped hay indicates promising results.

Forage in the Future. Engineers are on the job leading the way to the production of more prime forage. Their cooperative colleagues in plant science, biochemistry, animal breeding and other sciences are doing their part. Structures, machinery and equipment are being perfected. All at once there comes a realization that our old barn plans are obsolete while new designs are not available. Rural builders continue to build hay loft barns. New methods are not standardized and plans are not available. Nor will new designs be simple to prepare because of the many methods of forage production now available until standardization can be brought about.

Farmers are ready to go all out on change of forage production methods as soon as they can. How are they going to build that new barn now or in 1946 or 1948? Are we ready for the task and responsibility that is ours? If we don't have the answer, how many mistakes will be made? The response is that we do have some of the answers now; we are learning more almost daily, and our research is going as far and as fast as possible. Anything that can be done to secure support and help for the research, development, and design job ahead should be done promptly and vigorously. The trends to improved methods and improved forage are firmly established. Farmers will accept prime forage as fast as they can be shown how and equipped to produce it. They want more prime forage because it can provide more net profit with less hard labor.





(Left) This view shows the silos and ventilated structure for chopped dry hay on the Evans farm near Fall River, Wis. (Right) The buildings on the Larry Henning farm near Oconomowoc, Wis.

Artificial Drying of Combined Rice

By Kyle Engler and Xzin McNeal
MEMBER A.S.A.E. JUNIOR MEMBER A.S.A.E.

COMBINING and artificially drying rice is rapidly becoming the most acceptable method of harvesting. Rice was first combined in Arkansas in 1929 and some additional work was done in 1930 and 1931. The results of this work were published in USDA Circular No. 292, entitled, "Artificial Drying of Rice on the Farm". The results published have been used as a basis for all work in artificial drying of combined rice since that time.

The past few years have established this method of harvesting rice, but its expansion is being retarded at the present time by priority restrictions of the War Production Board. Even so, the commercial driers are increasing rapidly in numbers in all four principal rice-growing states, namely, California, Texas, Louisiana, and Arkansas. California reports over 60, Texas more than 20, Louisiana slightly less than 20, and Arkansas only 1. However, at the present time the Cooperative Rice Mill of Stuttgart, Ark., is building a completely modern monolithic concrete drier and storage unit. This drier is to be equipped with two stands of the largest Berico drier. It will be ready for use for the 1944 rice crop and will dry the rice for ten to fifteen of the Grand Prairie rice farmers.

In 1942 experimental work on artificial drying of combined rice was inaugurated in Arkansas at the Rice Branch Experiment Station under the supervision of E. L. Barger and other members of the agricultural engineering department of the University of Arkansas. An experimental farm unit drier (reported by Barger, Engler, and Thompson in AGRICULTURAL ENGINEERING for July, 1943) was successfully used in the 1942 and 1943 rice harvest. In 1942, 700 bu and in 1943, 6,000 bu of rice were dried by the experimental drier. In both years the drier proved entirely satisfactory and produced an excellent finished product with a controlled moisture content of from 13 to 15 per cent in the dried rice. Rice dried in this drier was sold to local rice mills at Stuttgart and DeWitt, Ark., and companion lots of binder-threshed rice were sold to the same millers when possible.

Without doubt the satisfactory work of this drier, together with the adoption of the combine and drier in Louisiana and Texas, has convinced the Arkansas rice farmer that he also can successfully combine and artificially dry his rice.

Advantages of Combining and Artificially Drying. Available information indicates that by the combine method of harvesting rice, five men will comprise the crew: two combines with two tractor-combine operators, one utility man, one truck driver, and the drier operator. This five-man harvesting crew would handle 20 acres of 50-bu rice, or 1,000 bu per day. This is a labor input of 5 man-hours to combine and dry 100 bu. This estimate is based on the assumption that the Arkansas rice farmer will use his present 5 or 6-ft pull-type combine. "The Rice Journal" for September, 1943, states, "B. A. Steinhagen and Sam Calder . . . will harvest approximately 7,000 acres with only three men — three men and a 16-ft Massey-Harris combine. Two additional men working at the farm elevator . . . . will prepare the crop for milling — two men and a Berico drier."

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis., June, 1944, as a contribution of the Farm Structures Division. Research paper No. 788, Journal Series, University of Arkansas; approved by the Director of the Arkansas Agricultural Experiment Station.

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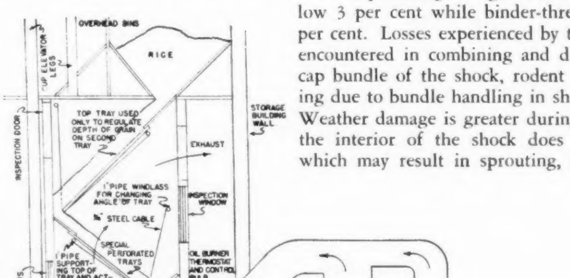

The farm unit rice drier developed by agricultural engineers at the Arkansas Agricultural Experiment Station

According to unpublished data by O. T. Osgood, University of Arkansas, on labor requirements in rice production, two men operating an 8-ft binder and four shockers will cut and shock slightly over 16 acres per day. The threshing crew is comprised of 12 men and 6 teams. This threshing crew will usually handle from 1,200 to 1,500 bu of rice per day depending upon yields and weather conditions. This is a labor input for the binder-thresher method of 16 man-hours of labor to cut and thresh 100-bu of rice, as compared with 5 man-hours of labor to combine and artificially dry 100 bu of rice.

The extreme labor shortage of the present time will undoubtedly influence many rice farmers to change from the present binder-thresher method of harvesting rice to the labor-saving method of combining and artificially drying.

The market value of a lot of rice is primarily determined by the percentage of the whole-grain rice that can be obtained from it. The hardness of rough rice (its resistance to breakage in milling) is commonly referred to as "milling quality." Therefore, the milling quality determines to a large extent the market value of rough rice. When damp or wet rice is milled, a larger percentage of the rice kernels break and thus reduce the yield of head rice. The milling quality of rough rice ordinarily increases with a decrease in moisture content until the moisture content has been reduced to between 12 and 14 per cent. The moisture content can be controlled by artificial drying. All lots of dried rice, except one, showed improved milling quality over companion binder-threshed lots. Improvement ranged from 4.1 to 5.2 per cent increase in value of the milled product. Reports from the Louisiana federal-state rice grading laboratory indicated that artificial drying increased the total milling yield of rice by approximately 10 per cent. It might be pointed out that the lot of combined Arkrose, which showed a decrease in milling quality, was a small lot, thereby making accurate milling yield determination difficult. Also, this field of rice had badly lodged before harvest and it did not mature as completely as the binder-thresher harvested lot.

To obtain maximum milling quality, it is desirable that rice be harvested either by the binder or the combine when the kernel has a moisture content between 20 and 26 per cent. Experience has shown that during the ripening period the standing grain will lose about 1 per cent moisture per day. Rice that is allowed to ripen much below 20 per cent moisture content is likely to become sun-checked, thereby reducing milling quality. During wet harvest seasons it is often impossible to operate a binder due to water standing in the field. However, the combine has been successfully operated in rice fields covered with water to a depth of 1 ft.

The percentage of grain loss in combining should be kept below 3 per cent while binder-thresher losses usually range above 5 per cent. Losses experienced by the binder-thresher method and not encountered in combining and drying are blackbird damage to the cap bundle of the shock, rodent damage in the shock, and shattering due to bundle handling in shocking and hauling to the thresher. Weather damage is greater during a warm wet harvest season when the interior of the shock does not have an opportunity to dry, which may result in sprouting, molding, and discoloration of the kernel. Hot dry weather may result in overdrying and consequent checking.

Combining and artificial drying insures that a certain portion of the rice crop is safely stored away each night from weather hazards, birds, and other possible losses. Rice is unusual in that combining and binding should be started at the same time and completed in the same period of time. When rice is allowed to stand until dry

enough for safe storage, excessive checking occurs and thereby reduced milling quality is encountered.

TABLE 1. COST PER BUSHEL OF REDUCING MOISTURE CONTENT OF RICE USING A MECHANICAL DRIER, AND THE EFFECT OF DRYING ON MILLING QUALITY, VALUE, AND GERMINATION, BY VARIETIES, RICE BRANCH EXPERIMENT STATION, 1943

	Rate through drier by runs, bu per hr				Air temperature by runs, F				Moisture content of rice, per cent			Cost per bushel to remove moisture, c				Milling Quality Determination*				Value of bushel at ceiling price†	Germination, %
Lot No.	1	2	3	4	1	2	3	4	In drier	Out of drier	Removed	Fuel	Electricity	Total	For 1%	Moisture, %	Weight per bu, lb	Head rice per bbl, lb	Total rice per bbl, lb		
Arkansas Fortuna																					
4-A-4	70	80	80	65	120	120	120	120	21.7	13.4	8.3	0.71	0.74	1.45	0.17	14.7	44.2	71.5	108.4	$1.75	93
4-B-4	60	60	60	60	120	120	120	115	17.7	12.2	5.5	.75	.92	1.67	.31	14.0	45.1	76.9	111.0	1.86	97
4-C-3	50	50	70		120	121	115		18.2	12.4	5.8	.57	.75	1.32	.23	13.5	43.3	76.9	110.2	1.82	95
4-D-2	72	70			121	120			17.8	13.0	4.8	.34	.37	.72	.15	14.9	44.4	78.2	110.2	1.83	97
4-E-2	80	80			130	121			17.4	12.6	4.8	.34	.34	.68	.14	13.7	45.0	78.5	109.0	1.82	92
4-F-2	70	75			125	115			18.2	10.9	7.3	.36	.38	.74	.10	13.2	45.1	74.2	110.5	1.80	
4-G-1	75				121				16.5	13.2	3.3	.21	.18	.39	.12	14.6	44.5	71.1	109.0	1.76	
Average											5.7	.47	.53	1.00	.17			75.3	109.8		
Arkrose																					
5-A-4	60	72	72	70	120	120	120	120	22.4	13.2	9.2	.77	.78	1.55	.16	16.1	47.2	93.2	111.0	1.70	87
5-B-3	60	70	81		130	130	130		21.0	13.9	7.1	.62	.58	1.20	.17	15.7	48.0	90.0	113.8	1.72	89
Average											8.2	.70	.68	1.38	.17			91.6	112.4		
Nira																					
6-A-3	60	75	90		130	130	130		20.9	12.7	8.2	.73	.57	1.30	.15	13.5	47.0	70.6	108.7	1.89	91
6-B-3	60	75	90		120	120	120		21.4	13.9	7.5	.63	.57	1.20	.16	14.5	47.8	62.5	107.1	1.79	
6-C-2	75	75			140	130			21.1	14.3	6.8	.45	.36	.81	.11	15.4	47.7	41.5	106.4	1.57	
6-D-3	70	80	90		130	130	130		21.0	12.8	8.2	.60	.52	1.12	.14	13.4	44.5	74.8	107.3	1.92	
Average											7.7	.60	.51	1.11	.14			62.4	107.4		
Zenith																					
3-A-4					120	120	120	120										87.0	110.3	1.63	

*Determined by Smith shelling device

†Ceiling price on November 30, 1943

Experimental Results for 1943. The experimental drier was operated a total of 306 hr from September 5 to October 11, 1943, or 35 per cent of the total time during this period. Four of the more common rice varieties used in Arkansas were combined and dried as follows: 1,220 bu of Zenith, 2,660 bu of Arkansas Fortuna, 650 bu of Arkrose, and 1,450 bu of Nira. An average of 7.2 per cent moisture was removed from the rice by the drier. The wettest grain contained 23 per cent moisture when combined, and the driest grain contained 16.5 per cent. In the former case, the rice was run through the drier four times, and in the latter case one time. The moisture content at combining was lower than desirable and probably resulted in slightly decreased milling yield. The 1943 harvest season was unusually dry and hot, which caused the rice to ripen rapidly. Dry-bulb temperatures of the drying air were varied from 115 to 140 F. The average cost of reducing the moisture of Arkansas Fortuna was 1.00 c per bu. It cost 1.37 c per bu to reduce the moisture content of Arkrose 8.1 per cent and 1.11 c per bu to reduce the moisture content of Nira 7.7 per cent. These costs included fuel and electricity only; no labor or overhead costs were included. Artificial drying had no effect on germination.

Table 1 shows the detailed results of the 1943 work. This table includes the rate at which the rice was put through the drier, temperature of the drying air, moisture content of the rice, cost of drying, effect on milling quality, value per bushel at ceiling price, and germination percentage of dried rice. In addition, the following actual milling yields were given by the commercial mills of Stuttgart and DeWitt: The combined-dried Arkansas Fortuna was undermilled and produced 92.5 lb of head rice and 116 lb of total rice per barrel (one barrel for 162 lb of rough rice). The companion lot of Arkansas Fortuna, also undermilled, was grown under similar conditions and when harvested with a binder at the same time, milled 87.3 lb of head rice and 113.5 lb of total rice per barrel. Using November 30, 1943, ceiling price, the combine rice was valued at 8c per bu (45 lb) more than the binder-threshed harvested lot.

The combined Zenith produced 80.2 lb of head rice and 111.7 lb of total rice per barrel. The companion lot of binder-threshed harvested Zenith milled 78.6 lb of head rice and 105.2 lb total rice per barrel. The combined and dried rice was valued at 8 c per bu more than the threshed lot. The combined Nira milled 83.25 lb of head rice and 120.5 lb of total rice per barrel. No companion lot of binder-threshed rice was available for check. Using ceiling price of November 30, 1943, this rice was valued at $2.18 per bu.

The experimental results of Table 1 were obtained from samples taken from the various lots of artificially dried rice. Actual milling yields from the commercial mills are not shown. The Smith shelling device was used to determine milling quality. Moisture determinations were made with the Tag Heppenstall moisture tester. The first figure in the lot number indicates the field, the letter indicates the day combined, and the last figure indicates the number of trips through the drier necessary for drying.

Air temperatures were varied from 115 to 140 F. The drying rate was varied from 50 to 90 bu per hr. The milling quality in all cases was satisfactory, except lot 6C2. This was a long-grain variety on which a drying temperature of 140 F was used the first trip through the drier and 130 F the second, reducing the moisture content 6.8 per cent. This indicates that a drying air temperature of 140 F and a drying rate of nearly 4 per cent moisture removed is probably too high for satisfactorily drying long-grain varieties. Experimental work is still needed to determine the relationship of milling quality to drying temperatures, drying rates, moisture content, and other factors. The commercial practice at present is to use drying air temperatures of 110 F or below, and the removal of 2.5 to 3 per cent moisture per trip through the drier on long-grain varieties.

The experimental results indicated that commercial practices are well within the safe drying ranges and also that higher drying temperatures and increased drying rates will prove satisfactory.

In an attempt to determine the maximum temperature allowable in storing rice, one lot was left in the tempering bin 48 hr and reached 117 F before running through the drier the second time. It was wet to the touch and had a definite fermented odor. The odor practically disappeared and the temperature was reduced to 100 F by the second drying. The third drying removed all objectionable odors and the excessive temperature. Two other lots were left in the tempering bins 36 hr after the first drying and reached 110 F. They also had a fermented odor which was removed by the second drying in each case. There was no evidence of permanent injury to the rice by any storage conditions encountered. Rice dried more readily when it was stored and permitted to heat slightly. However, it has not been determined how high the temperature may go or the duration of abnormal temperatures before milling quality is reduced or germination is destroyed.

A Study of the Centrifuge Moisture Equivalent as an Index of the Hydraulic Permeability of Saturated Soils

(A PROGRESS REPORT)

By Harry B. Roe and Joseph K. Park
FELLOW A.S.A.E. JUNIOR MEMBER A.S.A.E.

THE movement of water through both saturated and unsaturated soils is a prime consideration in both irrigation and drainage. The rate of movement is dependent upon the hydraulic gradient, h_t/L*, and upon the coefficient of hydraulic permeability, k_s†, for, by Darcy's Law of fluid flow through porous media,

$$v = k_s h_t / L \qquad [1]$$

In view of the fact that, in both irrigation and drainage, we are primarily concerned with vertical, downward flow, the assumption that the hydraulic gradient, h_t/L, equals unity introduces into practical problems no serious percentage of error. Determination of the coefficient of hydraulic permeability, however, presents serious practical difficulties. Numerical values of this coefficient are thus far available for only a negligible number among thousands of soils of differing character. Equipment and knowledge of procedures for making such determinations exist at relatively few places. Furthermore the determinations often take considerable time. For example, with one of the soils handled in this investigation, the determination of k_s was not completed at the end of 3 weeks, and in several other instances the time required was from a day or two to a week. The general problem is still further complicated by the fact that k_s for capillary flow in any unsaturated soil is apt to differ greatly in magnitude from that in the same soil when saturated. This study is limited to saturated soils.

This paper was prepared expressly for AGRICULTURAL ENGINEERING. Paper No. 2166, Scientific Journal Series, Minnesota Agricultural Experiment Station.

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*Hydraulic gradient, h_t/L, is the ratio of the effective head to the length of soil column and is therefore a pure number.

†Coefficient of hydraulic permeability, k_s, is defined by Meinzer as "the rate of discharge of water through a unit cross section of the rock (or soil) at right angles to the direction of flow if the hydraulic gradient is unity." This definition makes it clear that k_s is a velocity.

Since the centrifuge moisture equivalent, M_{eq}, is generally more readily and quickly determined than is the hydraulic permeability, this study was undertaken at the Minnesota Agricultural Experiment Station in the hope of finding a usable empirical relation between corresponding k_s and M_{eq} values. The moisture equivalent is used by more and more engineers, soil scientists, and physicists as it is an important and well-known property by means of which the physical character of a soil may be approximately determined. Since its value is known for so many soils throughout the country, the determination of a definite relationship between it and the hydraulic permeability of soils, if such a relationship exists, would greatly simplify the application to practice, of the law of water flow through soils.

Before the study was initiated the idea was presented to Dr. O. W. Israelsen, research professor of irrigation and drainage at the Utah State Agricultural College and Experiment Station. He was sufficiently interested that, on request, he furnished samples of 14 Utah soils and 2 Arizona soils for which he had already determined the k_s values used with those soils and presented in this paper. The centrifuge moisture equivalent of each of these samples was determined in triplicate in the laboratory of the division of soils at the Minnesota station. After plotting the corresponding values for these 16 soils on double logarithmic paper, the k_s values as ordinates and the M_{eq} values as abscissas, a careful preliminary study of the indicated relation between the two characteristics was made, but the data were far too meager to furnish a basis for definite conclusions. Therefore, the project was greatly extended, locally, and carried out as described in following sections of this report.

EXPERIMENTAL PROCEDURE

In this study the tests were made on laboratory prepared samples rather than on undisturbed field samples. On this point Krynine[3]‡ writes: "If the latter are perforated by plant roots and earth-

‡Superscript numbers denote the references appended to this paper.

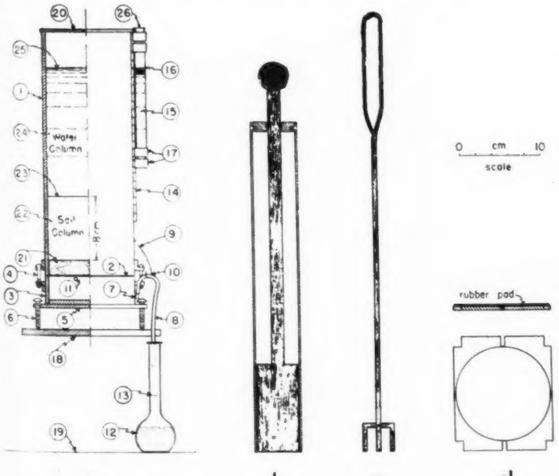

Fig. 1 Diagrammatic sketch, in elevation, of the permeameter and accessories. (a) Details of the permeameter: (1) iron cylinder 1 ft high and machined to an exact diameter of 10 cm, (2) Dur-loy wire cloth screen (80 openings per linear inch; diameter wire, 0.003 in) with rubber gasket vulcanized around its circumference, (3) basal receiving cup of iron (inner diameter, 10 cm), (4) screw clamps brazed to cylinder and basal receiving cup, (5) leveling plate, (6) leveling screws, (7) outlet valve, (8) small rubber tube (5 mm diameter) from outlet valve to flask, (9) fine wire stirrup to hold top of bend of rubber tube on under side of proper elevation, (10) small ventilator hole in top of bend of rubber tube to prevent siphon action, (11) small hole in top of wall of basal cup to relieve air pressure (stopped tight during a test), (12) volumetric flask, (13) calibrated gauge line on flask, (14) scale graduated in centimeters and in 10ths and 20ths of a centimeter, (15) standard ⅜-in gauge glass, (16) metal pointer, (17) standard brass stuffing connections and nipples for gauge glass, (18) foundation plate of glass or metal resting on main support, (19) top of work table, (20) square flat glass cover to prevent evaporation, (21) fine uniform sand filter 2 cm high, (22) soil column 8 cm high, (23) muslin-covered coarse wire screen, (24) water column, (25) surface of water column, (26) stopper of clean-out vent for gauge glass. (b) The standard tamper (weight of tamping lug, including rod and handle, 5½ lb). (c) Stirring fork for use in breaking up stratification of the soil column. (d) Tamping base of iron with thin rubber sheet hard-glued to top face to obviate crushing of soil particles

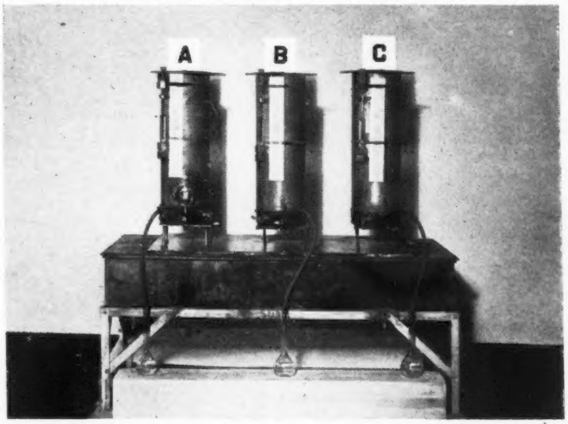

Fig. 2 The triplicate permeameters in their laboratory setup

worms as happens close to the surface of the ground, the permeability of the natural soil may be several hundred times higher than that of a disturbed sample. On many other occasions disturbed samples are more permeable than the undisturbed." It is probably just as true that undisturbed field samples from the same general location may vary widely from each other, depending upon crops and the condition of the soil. It should be further noted, also, that the influence of the factors mentioned by Krynine would be relatively slight in soils below the A horizon, in comparison with the influence of soil texture and structure. The authors felt that the use of laboratory-prepared samples would eliminate some of the special factors above named and confine the variations to factors depending more on the soil type alone.

In consultation with the division of soils, 52 representative Minnesota surface soils covering a wide range both geographically over the entire state, and in physical character from sands to clays inclusive, were selected as a basis for field accumulation of samples. Large samples of the 52 surface soils, all within the A horizon, were secured at the various locations, and similar samples of the corresponding subsoils, all within the B horizon, were likewise secured, except in one case where the water table was so high as to make the cost of securing this subsoil sample unjustifiably high as this one soil would represent less than one per cent of all those tested in this study.

The 103 Minnesota samples were next put through the customary treatment to prepare them for laboratory study.

Moisture Equivalent Determinations. Smaller representative samples were next prepared in the customary manner for centrifuge determination of the moisture equivalent of each soil, from 2 to 5 tests being made in each case until consistency in results was secured. The average M_{eq} values thus determined are shown in Table 1 for the 103 Minnesota soils and in Table 2 for the 16 arid soils.

Apparatus for Permeability Determinations. The next step was to design a permeameter suited to the study. Although some research reported by Krynine[3] indicates that Darcy's Law, above stated, seems not strictly applicable in all cases of flow of water through soils, the authors felt that they were justified in assuming its applicability for the ranges of gradients and soils in this study since Darcy's Law applies only to laminar flow, which is never exceeded in flow through soils.

The type of permeameter described by Jenkins[2] was adopted as a guide, with such modifications as were found necessary (Fig. 1). In order to aid in securing as nearly uniform and consistent results as possible in triplicate tests, three permeameters were built as nearly identical as it seemed possible to make them (Fig. 2).

To eliminate one possible variable, the final head, H_2, the authors decided to so design a permeameter that the hydraulic gradient would be essentially the same for all samples tested. This has the distinct disadvantage of increasing the time consumed in testing the heavier soils. The permeameter, as designed, is a variable head permeameter. However, in order to simplify both construction and manipulation, as well as to limit the number of variables to be measured with consequent increase in accuracy of results, by the simple mathematical transformation later shown, the final value of

TABLE 1. SOIL DESCRIPTIONS AND AVERAGES OF LABORATORY-DETERMINED VALUES OF THE HYDRAULIC PERMEABILITY, k_s, AND MOISTURE EQUIVALENT, M_{eq}, OF 52 MINNESOTA SURFACE SOILS AND THEIR CORRESPONDING SUBSOILS

(Symbols used: FSL, fine sandy loam; LFS, loamy fine sand; LS, loamy sand; SL, sandy loam; VFSL, very fine sandy loam; SiC, silty clay; SiCL, silty clay loam; SiL, silt loam; CL, clay loam)

Soil no.	Soil description — SURFACE SOILS	Average M_{eq} value, per cent	Average k_s value, cm/sec	No. of tests
1	Thurston SL, Hennepin Co.	5.12	6.35×10^{-4}	3
2	Cloquet FSL, Pine Co.	6.90	1.60×10^{-4}	5
3	Omega LFS, Pine Co.	7.07	2.37×10^{-4}	6
4	Aldrich LS, Wadena Co.	9.05	5.20×10^{-5}	3
5	Hayden SL, Hennepin Co.	9.35	4.33×10^{-5}	9
6	Bradford FSL, Mille Lacs Co.	10.72	7.67×10^{-5}	3
7	Ulen FSL, Polk Co.	11.25	4.05×10^{-4}	3
8	Hubbard FSL, Hennepin Co.	12.35	3.70×10^{-5}	6
9	Baudette VFSL, Lake of the Woods Co.	12.83	1.46×10^{-4}	3
10	Wadena L, Wadena Co.	13.13	1.43×10^{-4}	3
11	Hayden VFSL, Washington Co.	13.38	3.37×10^{-5}	9
12	Hubbard SL, Hubbard Co.	13.40	3.00×10^{-5}	6
13	Hubbard SL, Polk Co.	14.07	3.30×10^{-5}	3
14	Kittson SL, Roseau Co.	15.89	1.25×10^{-5}	6
15	Rockwood L, Wadena Co.	16.23	2.05×10^{-5}	3
16	Pelan L, Roseau Co.	17.05	1.81×10^{-4}	6
17	Santiago SiL, Washington Co.	19.73	4.24×10^{-5}	3
18	Lester SiL, McLeod Co.	20.23	4.33×10^{-5}	5
19	Milaca L, Mille Lacs Co.	20.32	4.91×10^{-5}	3
20	Taylor L, Lake of the Woods Co.	21.99	3.26×10^{-5}	3
21	Hibbing L. Pine Co.	22.40	1.03×10^{-5}	6
22	Benoit L, Stevens Co.	23.39	2.20×10^{-5}	3
23	Bearden SiL, Polk Co.	23.73	1.00×10^{-5}	7
24	Nebish L, Polk Co.	24.39	3.43×10^{-5}	6
25	Waukon L, Polk Co.	24.55	5.38×10^{-5}	3
26	Carrington SiL, Olmsted Co.	24.66	1.37×10^{-5}	3
27	Sarpy, SiL, Houston Co.	25.00	1.69×10^{-5}	3
28	Brickton SiL, Mille Lacs Co.	25.52	3.77×10^{-5}	3
29	Neresen SiL, Roseau Co.	25.90	1.91×10^{-5}	3
30	Clarion SL, Jackson Co.	26.25	2.07×10^{-6}	3
31	Onamia SiL, Kanabec Co.	26.60	4.93×10^{-5}	6
32	Glencoe SiL, McLeod Co.	26.61	1.87×10^{-5}	3
33	Warman SiL, Kanabec Co.	27.18	5.71×10^{-5}	6
34	Adolph SiCL, Mille Lacs Co.	27.49	1.45×10^{-5}	3
35	Tama SiL, Houston Co.	27.56	2.72×10^{-5}	3
36	Fayette SiL, Houston Co.	27.56	3.71×10^{-5}	3
37	Arveson SL, Polk Co.	28.42	5.59×10^{-5}	5
38	Malung SiL, Roseau Co.	29.16	2.47×10^{-5}	3
39	Barnes SiL, Lac Qui Parle Co.	29.36	2.53×10^{-5}	5
40	Wabash SiL, Houston Co.	30.07	2.09×10^{-5}	3
41	Marshall SiL, Rock Co.	30.45	2.07×10^{-5}	6
42	Webster SiC, Jackson Co.	31.15	1.40×10^{-5}	3
43	Clarion SiCL, Hennepin Co.	31.29	1.87×10^{-5}	3
44	Clarion SiCL, Faribault Co.	31.54	1.40×10^{-5}	3
45	Faribault C, Faribault Co.	33.57	1.65×10^{-6}	9
46	Delavan SiC, Faribault Co.	34.42	9.32×10^{-6}	3
47	Lamoure SiC, Jackson Co.	35.86	5.56×10^{-6}	9
48	Clyde SiC, Olmsted Co.	36.30	1.21×10^{-5}	3
49	Fargo C, Polk Co.	38.05	6.40×10^{-6}	3
50	Blue Earth SiCL, Faribault Co.	39.22	1.19×10^{-5}	3
51	Freer SiC, Mille Lacs Co.	39.32	2.73×10^{-5}	3
52	Barnett CL, Roseau Co.	40.38	2.92×10^{-6}	3

Soil no.	Soil description — SUBSOILS	Average M_{eq} value, per cent	Average k_s value, cm/sec	No. of tests
1	Hubbard S, Hubbard Co.	1.25	1.31×10^{-2}	6
2	Thurston S, Hennepin Co.	2.21	1.34×10^{-2}	3
3	Omega LFS, Pine Co.	2.38	3.45×10^{-3}	6
4	Cloquet FS, Pine Co.	2.57	1.07×10^{-3}	6
5	Ulen LS, Polk Co.	4.07	5.33×10^{-4}	3
6	Aldrich LS, Wadena Co.	4.08	7.21×10^{-4}	6
7	Rockwood LS, Wadena Co.	5.76	5.04×10^{-5}	8
8	Hubbard LS, McLeod Co.	5.93	1.86×10^{-3}	3
9	Baudette LVFS, Lake of the Woods Co.	6.72	5.48×10^{-4}	3
10	Pelan SL, Roseau Co.	7.17	1.96×10^{-3}	3
11	Milaca SL, Mille Lacs Co.	10.39	3.60×10^{-5}	3
12	Wadena L, Wadena Co.	10.48	3.50×10^{-4}	3
13	Hubbard L, Hennepin Co.	12.90	5.19×10^{-5}	5
14	Nereson L, Roseau Co.	13.64	1.99×10^{-5}	3
15	Sarpy L, Houston Co.	13.72	1.26×10^{-4}	4
16	Onamia L, Kanabac Co.	15.04	3.43×10^{-5}	3
17	Nebish L, Polk Co.	15.25	1.12×10^{-4}	3
18	Arveson L, Polk Co.	15.96	4.43×10^{-5}	6
19	Hayden L, Hennepin Co.	16.03	5.33×10^{-5}	6
20	Bearden L, Polk Co.	16.70	4.19×10^{-5}	5
21	Malung L, Roseau Co.	16.95	2.55×10^{-5}	3
22	Bradford L, Mille Lacs Co.	17.30	2.75×10^{-5}	3
23	Benoit L, Stevens Co.	18.23	4.24×10^{-5}	3
24	Adolph L, Mille Lacs Co.	18.37	2.59×10^{-5}	3
25	Warman L, Kanabec Co.	18.54	4.63×10^{-5}	3
26	Lester SiL, McLeod Co.	19.43	3.67×10^{-5}	3
27	Taylor L, Lake of the Woods Co.	19.91	4.93×10^{-5}	6
28	Waukon L, Polk Co.	20.37	1.06×10^{-6}	3
29	Freer SiL, Mille Lacs Co.	20.66	4.60×10^{-5}	3
30	Carrington SiL, Olmsted Co.	21.13	1.66×10^{-5}	3
31	Webster SiL, Jackson Co.	21.39	1.32×10^{-5}	3
32	Tama SiL, Houston Co.	22.17	4.24×10^{-5}	6
33	Santiago SiL, Washington Co.	23.09	3.12×10^{-5}	3
34	Barnes SiL, Lac Qui Parle Co.	23.34	2.15×10^{-5}	3
35	Glencoe SiL, McLeod Co.	23.36	1.38×10^{-5}	3
36	Clarion SiL, Jackson Co.	23.40	2.59×10^{-5}	3
37	Kittson SiL, Roseau Co.	23.49	6.76×10^{-6}	5
38	Hayden SiL, Washington Co.	23.52	1.73×10^{-5}	3
39	Clarion SiL, Hennepin Co.	24.54	1.00×10^{-5}	3
40	Barnett SiL, Roseau Co.	24.87	3.39×10^{-6}	6
41	Clarion SiL, Faribault Co.	25.70	1.07×10^{-5}	8
42	Fayette SiL, Houston Co.	26.37	3.27×10^{-5}	6
43	Clyde SiCL, Olmsted Co.	26.80	2.34×10^{-5}	3
44	Blue Earth SiCL, Faribault Co.	28.45	6.47×10^{-6}	3
45	Marshall SiCL, Rock Co.	28.80	1.61×10^{-5}	3
46	Brickton SiCL, Mille Lacs Co.	29.66	9.70×10^{-6}	6
47	Lamour SiCL, Jackson Co. (No sample secured on account of water)			
48	Fargo C, Polk Co.	31.29	8.25×10^{-7}	4
49	Faribault SiCL, Faribault Co.	31.80	1.86×10^{-6}	5
50	Wabash SiCL, Houston Co.	32.37	1.72×10^{-5}	3
51	Hibbing SiCL, Pine Co.	32.87	1.52×10^{-6}	6
52	Delavan SiCL, Faribault Co.	39.22	5.12×10^{-7}	6

TABLE 2. SOIL DESCRIPTIONS AND AVERAGES OF LABORATORY-DETERMINED VALUES OF THE HYDRAULIC PERMEABILITIES k_s, AND MOISTURE EQUIVALENTS, M_{eq}, of 16 ARID REGION SURFACE SOILS FROM UTAH AND ARIZONA
(Furnished by Dr. O. W. Israelsen)

Soil No.	Soil description	Average M_{eq} value, per cent	Average k_s value, cm/sec
1	Arizona Sand, All-American Canal near Yuma, Arizona	7.4	1.4×10^{-4}
2	Sandy Chalk, Delta area, Delta, Utah	21.8	6.5×10^{-5}
3	Oasis Clay, Delta area, Delta, Utah	26.4	1.86×10^{-8}
4	Oasis Clay, Delta area, Delta, Utah	26.4	3.15×10^{-8}
5	Oasis Clay, Delta Area, Delta, Utah	28.2	2.26×10^{-8}
6	Woodrow Clay, Delta area, Delta, Utah	30.1	4.7×10^{-7}
7	Woodrow Clay, Delta area, Delta, Utah	32.3	1.3×10^{-7}
8	Arizona Clay, All-American Canal near Yuma, Arizona	32.9	2.0×10^{-7}
9	Black Rock Clay, 45 miles south of Delta, Utah	37.4	7.6×10^{-7}
10	Deltasite, 45 miles south of Delta, Utah	42.4	1.0×10^{-5}
11	Oasis Clay, Delta area, Delta, Utah	45.2	2.49×10^{-8}
12	Oasis Clay, Delta area, Delta, Utah	46.9	2.11×10^{-8}
13	Black Rock Clay, 45 miles south of Delta, Utah	47.5	7.6×10^{-8}
14	Green Bentonite, Redmond, Utah	52.0	4.4×10^{-8}
15	Goss Clay, 30 miles southwest of Delta, Utah	58.5	6.7×10^{-8}
16	Gray Bentonite, Redmond, Utah	82.9	5.6×10^{-8}

the head, H_2, was eliminated from the formula. The remaining variables to be measured then were initial head, H_1; volume of water collected, V; temperature, T; and time, t. (See details of development of formula and Fig. 1.)

Procedure. So far as the authors could determine very little published data are available regarding permeability tests on disturbed samples in the laboratory and there seems to be very little information about problems encountered by others in preparing disturbed laboratory samples for permeability tests; hence they were guided in this only by their own findings.

A considerable number of preliminary test determinations were made in triplicate for the purpose of finding the best methods of procedure regarding preparation and packing of sample. During these tests one problem was that of choosing a filter to be used at the bottom of the layer of soil. It was finally decided that a 2-cm layer of *fine sand* gave the least difficulty and most consistent results. This selection was made because it was found that fine sand in no case slowed up the rate of downward percolation by an amount that exceeded that caused by the most permeable of the experimental soils.

The soil column is composed of air-dry soil thoroughly mixed and finally compacted in the apparatus previous to the run, by the standard approved method modified in the manner described in the following discussion. It was found that, even when the greatest possible care was exercised in placing the soil in the permeameter simply by pouring it in three layers of approximately equal thickness, each of which was separately tamped, the pulverized soil always tended to deposit itself in strata according to size of soil particle. Of even greater importance was the fact that in the process of pouring and tamping, vertical veins or strata of the coarser material were formed through which the water percolated downward much more rapidly than through other parts of the soil column. The combination of these conditions resulted in serious lack of consistency in triplicate checks.

To attempt to stir the soil within the apparatus before compaction would introduce the danger of disturbing the sand filter and would encourage horizontal stratification. However, since it would apparently reduce vertical veining, the soil was stirred with a special fork shown in Fig. 1c. A layer of thickness approximately one-third the height of the soil column was poured into the cylinder, stirred with the fork, and then tamped with the standard tamper according to standard procedure. Then a second and third layer were placed in the same way until the desired total height of soil column was obtained. This procedure greatly improved the consistency of behavior of the triplicate tests but satisfactory consistency of results was not obtained in about one-half the cases. Although there may be objections to this detail of procedure, it was used because it seemed to give less variations in the triplicate checks. Moreover, it seems probable that, even considering the existence of the undesirable conditions above described, the disturbed samples in the triplicate permeameters would give no wider variation in k_s values than would result from contemporaneous tests of undisturbed soils in a given field.

The method having been thus standardized, the k_s value of each of the 103 Minnesota soils collected was determined in triplicate runs and these were repeated in any case found necessary, until consistency of results acceptable to the authors was obtained in the three sets of apparatus. The average k_s value for each soil thus determined is shown in Table 1 along with the previously determined M_{eq} values. The values of k_s given in Table 2 for arid region soils were measured with a variable head permeameter of somewhat different type in the irrigation department laboratory of the Utah Agricultural Experiment Station by Dr. Israelsen. The purpose of the Utah permeability measurements was to find soil materials suitable for lining irrigation canals to reduce seepage losses. No determinations of the voids ratio or specific weight of the sample were made on the samples tested.

It has been suggested by Gilboy[1] that organic decomposition and growth of fungi may effect the k_s values in cases where the determination takes considerable time. These influences were not investigated by the authors of this paper but are believed to be of secondary importance.

Computations. As previously stated the mathematical design is based on the assumption that Darcy's Law is applicable in the determination of k_s. In the development of the formula for k_s to be used with the laboratory data the following symbols are used with meanings as noted:

A = area of water and soil column cross section in square centimeters
h_t = effective head in centimeters at any instant
H_1 = effective head at beginning of a test, in centimeters
H_2 = effective head at the end of a test, in centimeters
L = height of soil column in centimeters
q = rate of discharge at any instant, in cubic centimeters per second
t = the general expression for time in seconds
t_1 = time equivalent at the beginning of a test, in seconds
t_2 = time equivalent at the end of a test, in seconds
$t_2 - t_1$ = length of run in seconds
T_{20} = temperature correction factor (determined in each case from Table 3 or Fig. 3) required to reduce the k_s value measured at the temperature during the given test to its corresponding value at 20 C.
v = velocity of flow in centimeters per second
V_c = total volume, in cubic centimeters, of material in the cylinder, at any instant, between the water surface and the base of the soil column
V_{1c} = the value of V_c at the beginning of the test
V_{2c} = the value of V_c at the end of the test
V = the total volume, in cubic centimeters, discharged in time $(t_2 - t_1)$. It is *negative* in algebraic character because it is a decrease in V_c.

As before stated Darcy's Law is

$$v = k_s h_t / L \qquad [1]$$

By the law of continuity of flow

$$q = Av = Ak_s h_t / L \qquad [2]$$

But

$$V_c = AH_t \qquad [3]$$

Then the decrease in V_c in an interval of time, dt, or

$$dV_c = -q dt = -(Ak_s h_t / L) dt \qquad [4]$$

Dividing equation [4] by equation [3], member for member

$$\frac{dV_c}{V_c} = -\frac{k_s}{L} dt \qquad [5]$$

Integrating equation [5] between limits shown below

$$\text{Log}_e V_c \Big]_{V_{1c}}^{V_{2c}} = -\frac{k_s}{L} t \Big]_{t_1}^{t_2} \qquad [6]$$

$$\text{or } \text{Log}_e \frac{V_{2c}}{V_{1c}} = -\frac{k_s}{L} (t_2 - t_1) \qquad [7]$$

But

$$V = V_{1c} - V_{2c}, \text{ or } V_{2c} = V_{1c} - V \qquad [8]$$

And, since $V_{1c} = AH$, substituting these values of V_{2c} and V_{1c} in equation [7]

$$\text{Log}_e \frac{AH_1 - V}{AH_1} = -\frac{k_s}{L} (t_2 - t_1) \qquad [9]$$

$$\text{Whence } k_s = -\frac{L}{t_2 - t_1} \log_e \frac{AH_1 - V}{AH_1} = -\frac{L}{t_2 - t_1} \log_e \left(1 - \frac{V}{AH_1}\right) \qquad [10]$$

Making temperature corrections to 20 C and converting from Naperian to common logarithms

$$k_s = -\frac{2.303LT_{20}}{t_2 - t_1} \log_{10}\left(1 - \frac{V}{AH_1}\right) \qquad [11]$$

TABLE 3. VISCOSITY OF WATER

Temp., C	Viscosity coeff., η (cgs)	$T_{20} = \eta$ test / η 20	Temp., C	Viscosity coeff., η (cgs)	$T_{20} = \eta$ test / η 20
0	0.01792	1.7831	55	0.00506	0.5035
5	.01519	1.5114	60	00.469	0.4667
10	.01308	1.3015	65	.00436	0.4338
15	.01140	1.1343	70	.00406	0.4040
20	.01005	1.0000	75	.00380	0.3781
25	.00894	0.8896	80	.00357	0.3552
30	.00801	0.7970	85	.00336	0.3343
35	.00723	0.7194	90	.00317	0.3154
40	.00656	0.6527	95	.00299	0.2975
45	.00599	0.5960	100	.00284	0.2826
50	.00549	0.5463			

NOTE: 40 F = 4.44 C
80 F = 26.67 C

Values of η taken from "Handbook of Chemistry and Physics."

Following is a specimen of the experimental data and computation sheet used for each separate run, the separate sheets for each apparatus of a triplicate run being always numbered A, B, and C, from left to right as shown in Fig. 2.

SOIL PERMEABILITY TEST DATA

L = cm (always taken at 8 cm) — Soil No. 30s* — Cylinder A — M_{eq} 32.37

Date	Clock time	Run no.	Head gage reading (H), cm	Actual head, cm	Temp., C	Time, min-sec	Time, sec	Measured V, cc
	8:12		16.05	24.05				
2-17-43	9:41	1	15.76	23.76	20.0	89 - 5	5345	25

A = 100 sq cm

L = 8 cm

For conveninence repeating Formula [11]

$$k_{s20} = -\frac{2.303LT_{20}}{t_2 - t_1} \log_{10}\left(1 - \frac{V}{AH_1}\right)$$

*Subsoil No. 30 marked 30s on the laboratory sheets.

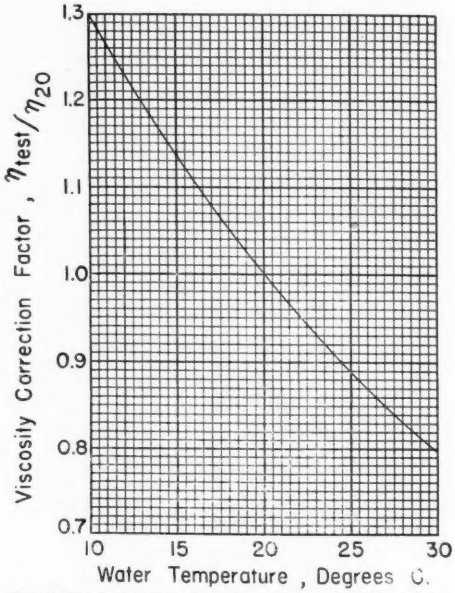

Fig. 3 Chart showing viscosity correction factors for different temperatures

Computations (head volume method)

Run no.	Meas. V, cm³	H_1	$\frac{V}{AH_1}$	$1-\frac{V}{AH_1}$	$-\text{Log}_{10}\left(1-\frac{V}{AH_1}\right)$	Temp. corr., T_{20}	Time, sec	k_{20} cm/sec
1	25	21.05	0.013235	0.986765	−0.00579	1.000	5345	1.995x 10^{-5}

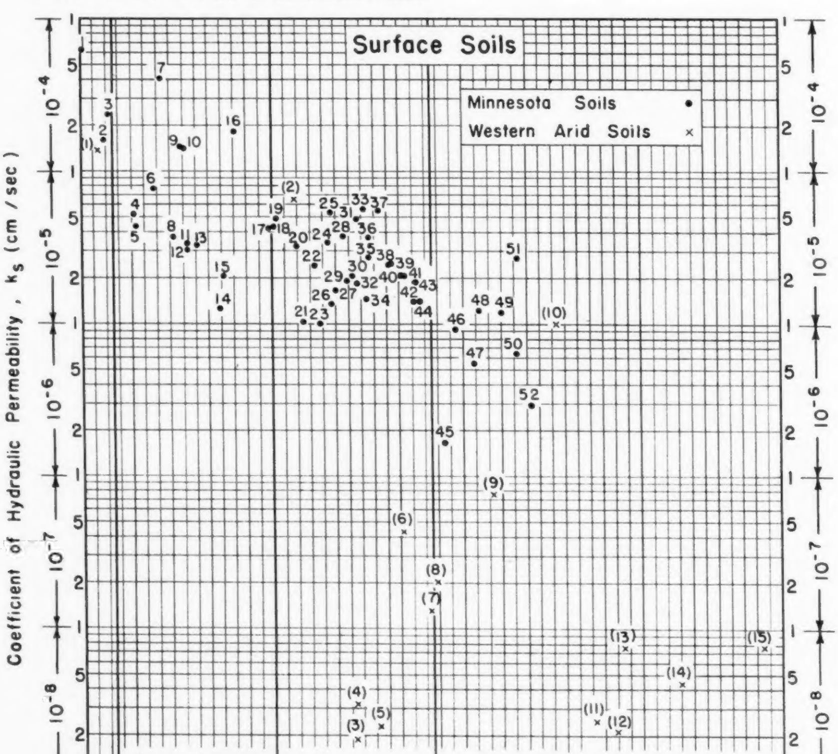

Fig. 4 Relation of the hydraulic permeability to the moisture equivalent (surface soils)

ANALYSIS OF DATA

The average k_s values as entered in Table 1 were plotted as ordinates on double logarithmic graph paper against the corresponding M_{eq} values as abscissas. Although there was a noticeable trend toward the type of mathematical relationship hoped for, the experimental values clearly showed too wide a deviation from any exact empirical rule to be of value in practical determinations of k_s values of soils on which no laboratory determinations had been made. Deviations of several hundred per cent were noticeable in several instances.

Although it is evident that the correlation is very bad, these data may be of some value in making rough estimates of permeability coefficients in cases where moisture equivalents are known. While such estimates may be highly inaccurate, they are better than judgment alone as the data give some basis for judgment. For the possible use of this data for such purposes, it was considered advisable to replot the data on semilogarithmic graph paper, the k_s values on the logarithmic scale as ordinates and the M_{eq} values on the rectilinear scale as abscissas. This was done, thereby making the soil class zones, as marked out by the M_{eq} values, more readily comparable. This result tends

to clarify the use of the charts. Fig. 4 represents the surface soils and Fig. 5 the subsoils. The arid region soils are shown in Fig. 4 along with the Minnesota soils with the exception of number (16) which was so high on the M_{eq} scale as entirely to remove it from comparison with the others.

A comparison of Figs. 4 and 5 shows two things that, while somewhat disconcerting, should not be overlooked in the use of the charts: (1) The surface soils show a more pronounced scatter than do the subsoils. This may safely be assumed to be due to the continual disturbance of the surface soils in the field procedures of farming and to the greater proportion of humus and other organic substances than is found in the subsoils. (2) The arid soils apparently show much wider dispersion and markedly different trends than do the soils from the semihumid region of Minnesota. This may be due to the general difference in their physical characteristics as a consequence of the different nature of the processes by which arid soils and humid soils are formed, those of the former being largely physical while those of the latter are largely chemical.

In commenting on a preliminary report by the authors, submitted to him by Dr. Israelsen, Dr. C. W. Lauritzen of the U. S. Soil Conservation Service suggested that a grouping of the soils according to physical and chemical properties would probably result in a better correlation than that shown by the moisture equivalent. The authors considered that, but it seemed clear that such a grouping would defeat the original purpose of these studies by making the application of Darcy's Law more complex instead of less so. They realized that the correlation sought by them would be influenced by the physical and chemical characteristics of the soils, but they did not anticipate a correlation as poor as that obtained.

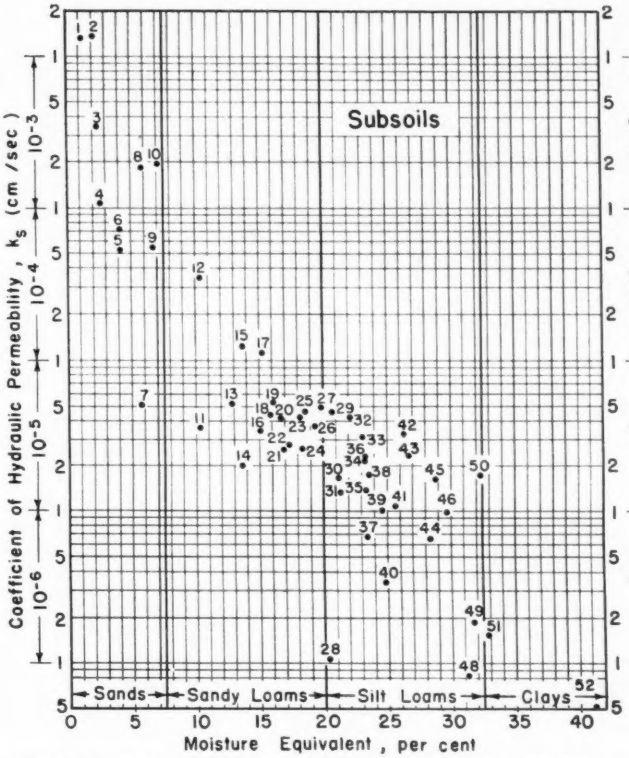

Fig. 5 Relation of the hydraulic permeability to the moisture equivalent (subsoils)

The authors still feel that a search for a relationship between k_s and a soil property more easily determined is desirable from a practical standpoint and that further studies to that end should be provided for in the near future.

CONCLUSIONS

No mathematical relationship between moisture equivalent and hydraulic permeability sufficiently reliable for direct application to practical problems is indicated by this study.

A general trend is sufficiently clearly indicated that it should serve as a guide to the judgment in selecting the probable range of k_s values for a given soil whose moisture equivalent is known, where the laboratory determination of the exact k_s cannot seem to be readily provided for.

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2 Jenkins, Herbert T. "Soil Mechanics Laboratory Manual — Physical Properties of Soils." Cornell University School of Civil Engineering, Ithaca, N. Y., 1939.

3 Krynine, D. P. "Soil Mechanics." McGraw-Hill Book Company, New York, 1941.

Postwar Farm Structures

PROMPT action is required if engineering design is to contribute fully to the development of farm structures in the postwar period, and there is increasing evidence that such action will be forthcoming. The state colleges of agriculture have recently prepared reports on a program for rural housing and farm building after the war. In these reports, there is a nearly unanimous agreement concerning the need for extensive research and educational aid for the development and improvement of farm buildings. County farm and home extension agents, vo-ag teachers, materials dealers, and rural builders are in position to render outstanding assistance in farm structures improvements, and they are demanding planning aids and technical information as a basis for service to farm families. The industries have indicated their interest by aggressive support of proposals for public aid to education and research and by increased contributions to cooperative investigations. Conferences of research workers in the north central region have been held recently to plan a unified program of investigation of regional significance.

Postwar Employment

TO THE EDITOR:

AN article in AGRICULTURAL ENGINEERING for June by T. B. Chambers, entitled "Postwar Opportunities for Agricultural Engineers in Soil and Water Conservation", was most interesting and enlightening. He tells of the tremendous amount of work in farm terracing and stock water reservoirs that lies ahead. This field should become a factor in postwar employment.

I have been constructing terraces and farm reservoirs with power equipment for Shelby County (Ky.) farmers for about nine years and have hardly scratched the surface of the possible work that could be done. Terracing is paying fancy dividends annually to farmers who are taking part in the program.

Shelby County is only one of at least fifty counties in Kentucky which could support two or more organizations similar to mine. Four hundred men would have year-round employment. Each company would have around $25,000 worth of equipment which would be replaced on an average of every five years. This would mean an annual sale of $500,000 worth of equipment by Kentucky dealers, and operating costs of about $1,000,000.00 annually would go to local business firms.

Does all this sound fantastic? It is working for me, and I believe it will work for the other fellow. Even with all the efforts that the U. S. Soil Conservation Service has put forth, we continue to lose the battle against erosion at an alarming rate. We must save the soil that is left, and I believe this can be done by private enterprises and that the farmer is willing and able to finance the job.

W. FORREST SMITH

Owner, Forrest Smith Terracing Co.
Shelby County, Kentucky

(EDITOR'S NOTE: Following are Mr. Smith's conclusions as to the comparative effectiveness of erosion control practices: (1) On land that is strip-cropped the movement of soil continues and will eventually reach the lowland. (2) On land contour-cultivated by eye, while erosion is checked, its deadly work continues. (3) Land sown to cover crops will do well during the ensuing years but the mark has been missed so far as protecting the field from erosion is concerned. (4) On the other hand, land terraced is permanently protected, that is, as long as the terraces are properly maintained.)

Checkrow Planting at Higher Speeds

By A. C. Sandmark

WITH the advent of the modern farm tractor most farm operations were speeded up. However, the checkrow planting of corn did not lend itself to faster tractor speeds, because the conventional valves used were not capable of bunching the hills of corn properly at speeds over 3 or 3½ mph. The only advance made was to increase the width of the planter from two to three or four rows, but the speed could be no greater than that of horses.

Timeliness of planting corn is very important. If it can be done at just the right time, it may mean a great difference in the yield, as well as mature it ahead of an early frost. The farmer who can get planting done quickly ahead of a wet spell also gives his crop a start that puts it way ahead of his slower neighbors. The scarcity of hired help has also made it desirable to increase the daily capacity of the planter.

It was for these reasons that our company started about eight years ago to develop new two and four-row tractor planters that would speed up checkrow planting about 50 per cent, or give a planting speed of 5 mph. In developing these planters, the use of a high-speed motion picture camera was of great assistance because by means of slow-motion pictures, it was possible to see in great detail the movement of each kernel of corn as it passed through the valves. After much study it was found that there were three things happening to the kernels which prevented checkrow planting at higher speeds.

1 The rebounding or bouncing of the kernels when they hit the flat surfaces which, at various planes or wide angles formed the bottom of the valves of all planters, prevented higher speeds. This was because the time interval between valve openings was much less at higher speeds and the kernels would not have come to rest at the time the valves were opening thus causing a mixing as well as scattering of hills. To illustrate, if a kernel bounced up only one inch, the planter would move forward about a foot at 5 mph before that kernel would settle down into the valve again. Many times the kernels bounced considerably more than an inch so that it was easy to see that this took too much time to permit higher valve speeds.

2 In falling from the upper to the lower valves, the kernels would not always fall in a compact bunch, but would scatter or string out. This prevented higher speeds because it took too long for all the kernels to settle into the lower valve, which they must do before they could be ejected.

3 When the lower valve ejected the kernels into the ground, the ejecting face of the valve or plunger would be moving at high speed when it struck the kernels composing the hill of corn, thus kick-them out with considerable impact. Kicking or batting the kernels out would cause them to scatter, and this scattering of hills became more pronounced as the speed of planting was increased.

To overcome these faults, new upper and lower valves were designed which had very narrow V-shaped pockets. The upper valve was made to form an upright narrow V-shaped pocket, when in the closed position, and it could be opened very quickly by moving one side away from the other at the lowest point of the V. The lower valve was made to form a V-shaped pocket curved forward at its lower end when closed. The lower or rear part of this V consisted of a gate which, when the valve was opened, moved downward and backward very quickly out of the path of the ejected hill. The upper or forward part of this curved V served as the ejecting surface which was always in contact with the kernels of corn before they were ejected and thus pushed the hill of corn out with a downward as well as backward motion when the valve was opened.

Let us see how this construction could overcome the three faults mentioned above:

1 When dropping into the narrow V-shaped pockets, the rebounding oscillations of the kernels were dampened, and they came to rest quickly between the walls of the valves, being wedged as it were at the point of the V. This reduced the time necessary between valve openings and therefore permitted higher valve speeds.

2 This construction also made it possible to drop the entire hill of corn in a compact bunch from the upper to the lower valve. The reason all kernels dropped together was because the instant the upper valve started moving open all kernels were released together, while in most conventional upper valves some kernels might fall as the valve started to open, but there was no assurance they would all fall until the valve was wide open. The new valve also provided a smooth tube or passageway from the upper to the lower valve thus eliminating any moving surface which would tend to scatter the kernels as they fell. By preventing the scattering of the hill in falling from upper to lower valve, all the kernels reached the lower valve more quickly and thus further reduced the time necessary to get the kernels settled in the lower valve.

3 The new construction pushed the hill of corn out of the lower valve instead of kicking or batting it out. It was noticed that when the hill was kicked out by a sharp impact from a fast-moving valve surface or plunger, it would scatter more than when pushed out. This was because the seeds may lie in different positions and thus be struck at different points relative to their center of gravity. In the new high-speed valve, the surface that ejects the hill is in contact with the kernels before it starts to move; therefore, it ejects the seed with a general pushing action, which, even though rapid, maintains the seed in a relatively small bunch. In fact, the hills were found to be better bunched with the new valves at 5 mph than with the old valves at 3 or 3½ mph.

Other features built into these planters also cut down the planting time and assure a satisfactory job.

This development, which has made it possible to speed up greatly the operation of planting of corn, is an engineering achievement of much significance, and it is of inestimable value to the farmer in enabling him to plant his corn under more favorable weather and soil conditions.

This picture shows both the upper and lower valves of the Deere high-speed corn planter, with kernels of corn in each ready for ejection. To obtain this view, the shank as well as the sides of the valves had to be cut open

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis., June, 1944, as a contribution of the Power and Machinery Division.

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Time and Labor-Saving Possibilities of a High-Speed Drill Planter

By H. V. Hansen
MEMBER A.S.A.E.

IT IS a well-known fact that corn is crosschecked with a checkrow planter for one purpose — to help control weeds. A field of corn properly crosschecked can be cultivated both with direction of planting and at 90 deg to the direction of planting. The first four states — Iowa, Illinois, Indiana, and Minnesota — having the highest yields per acre, respectively, use checkrow planters very extensively.

The next six states — Missouri, Texas, Georgia, Nebraska, Kansas, and South Dakota—use a few checkrow planters in some areas, but drill planters and listers are used to a greater extent. In these areas moisture is more important than weed control made possible by crosschecking.

In soil conservation areas contour farming is practiced, and it is of course impossible to crosscheck corn and plant on the contour at the same time. Here again drilling of corn on the contour as a conservation measure is more important than crosschecking for easier and more effective weed control. Data from the USDA-SCS regional office at Spartanburg, S. C., show an increase of corn yield per acre on 1754 southeast farms of 42.4 per cent due to conservation practices. The Iowa Agricultural Experiment Station and the Soil Conservation Service in 1942 compared the yields on 30 fields of corn and reported an increase in yield of 6.2 bu per acre.

What has increased yields in contour farming to do with the time and labor-saving possibilities of a high-speed drill planter? Just this: Drill planters are necessary to plant on contours, and farmers have turned to drill planters to save their land and increase their yields.

Agricultural engineering treats in part of labor efficiency, power economy, and effective use of mechanical equipment. The foregoing mention of contour farming brings in yields per acre, conservation of fertility, and total production, but the effectiveness of the individual laborer is becoming more and more important.

One way to show the labor-savings possibilities of a drill planter is to show the loss of time in the use of a checkrow planter.

The leading planter manufacturers use one of two types of checkrow wire anchor stakes, either the tension meter type or the payout type. An explanation of these types has no place in this paper, but they are well known to those familiar with corn planters. There are other types of wire-handling mechanism, such as crossover wire mechanism, that are not used extensively enough to warrant time for discussion.

Planting speed has been increased from 3½ to 5 mph and crosschecking has been satisfactorily accomplished at this increased speed. An increase of 1.5 over 3½ mph means an increase of 42.9 per cent during the time the planter is operating, which is the basis from which we must start in determining how much time and labor can be saved by drilling.

It must be understood that turning time at the ends of the field is not included in the figures given in the following paragraphs, since turning time either in checkrowing or drilling should be the same. Also the time needed to unreel and reel the checkrow wire is not included since it is possible to drill the first one-half round while unreeling the wire and the last one-half round while reeling the wire. There would be a small time loss but the percentage would be very small.

The time given as time required to set the checkrow wire stake is taken from the moment the clutch is thrown out on a tractor after turning at the end of the field until the time the clutch is thrown in as planting is resumed. The shape of the field has both ends parallel which is ideal for checkrow planters inasmuch as no buttons need be taken up or let out at either end.

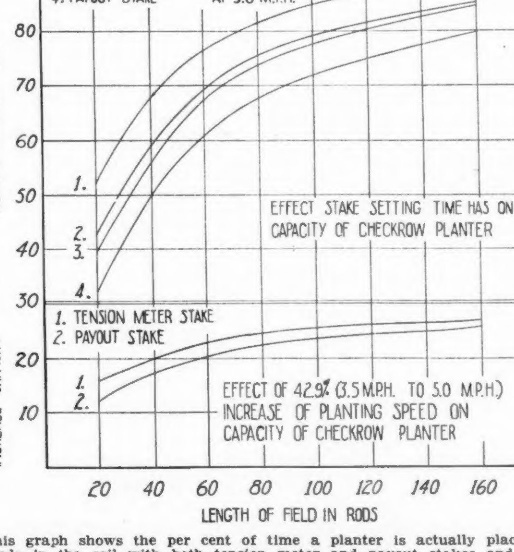
The time required to set the checkrow wire stakes was obtained from actual time studies made in the field in 1941. Each of the operators had planted at least 400 acres of corn that season and were skilled operators. The time required to travel the length of the field is obtained mathematically assuming a uniform speed of either 3½ or 5 mph.

The accompanying graph shows the per cent of time a planter is actually placing seeds in the soil with both tension meter stakes and the payout stakes and operating at both 3½ and 5 mph.

There are 213,318 farms in Iowa that average 160.10 acres each, 44.5 per cent of which is planted to corn each year. With this as a base the graph gives only time studies up to and including 160-rod rows. The average would be considerably less than 160 rods. It is interesting to note on 20-rod rows, using a tension meter stake and traveling at 3½ mph, that 48 per cent of the time is lost; and 57 per cent is lost traveling 5 mph. With a payout stake at 3½ mph, 56 per cent is lost; and 67.6 per cent is lost at 5 mph. The planting time increases with the length of row, very rapidly at first and then levels off.

A larger per cent of time is lost traveling at 5 mph than at 3½ mph. This can easily be realized since the time it takes to set the stake is constant and the time required to cross the field is decreased, thus raising the percentage. It is interesting to note that even at 160-rod row lengths and traveling at 3½ mph, there is 10.4 per cent of time lost because of the stake; and 14.3 per cent at 5 mph. With the payout stake the percentages drop to 14.8 per cent at 3½ mph and 20 per cent at 5 mph.

The two lower curves in the graph show the actual increase in planting capacity due to the 42.9 per cent increase in speed, obtained by traveling at 5 mph instead of 3½ mph. These increases run from 15.8 to 27.1 per cent with the tension meter stake and from 12.5 to 25.8 per cent with the payout stake on 20 to 160-rod rows, respectively. This is a remarkable increase, but there is still a time loss of 67.6 per cent on 20-rod rows and 10.4 per cent on 160-rod rows. A drill planter will gain the above percentage lost because this loss is due only to moving the checkrow wire stake. When agricultural engineers build into a machine a 10 per cent capacity increase it is an accomplishment. Here (*Continued on page 392*)



This graph shows the per cent of time a planter is actually placing seeds in the soil with both tension meter and payout stakes and at both 3½ and 5 mph speeds

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Nutritional Values of Hay and Silage as Affected by Harvesting, Processing, and Storage

By G. Bohstedt

(*Concluded from the September issue*)

PART II. HARVESTING, PROCESSING, AND STORING SILAGE

AS WITH hay, so with silage, there are principles and methods of conserving most of the original nutritive value of the fresh forage. Essentially these are (1) to exclude or sufficiently restrict air and (2) to have a relatively high acidity, anywhere from about pH 3.5 to pH 4.5. Both requirements may be brought about by proper moisture and sugar contents of the forage to be ensiled. In the humid regions of the country it is as a rule easier to preserve the nutrients of a forage crop by ensiling than by hay making.

Acidity Is Best Single Criterion of Quality in Silage. Where the single criterion of high carotene content ordinarily denotes high-quality hay, so the single figure of high acidity marks high-quality silage. Naturally in either case the palatability and other characteristics of the original forage are factors in the over-all feed value. If, for instance, sawdust should be put into the silo, no matter what preservatives are used, sawdust would be taken out.

Therefore, as in the case of hay, the higher the original feed value of the crop and the younger the crop or the nearer it is to the pasture stage of growth, the more nutritious the resulting silage. There is a reasonable limit in respect to maturity, for to ensile a crop when very young may, on account of the low yield per acre, be economically impractical. Also in the case of alfalfa or some other crop, its survival may be jeopardized.

Furthermore, a succulent young crop may press into such a compact, water-logged condition in the silo that too little air or oxygen is provided. As a result, respiration of plant cells is prematurely stopped, leaving a rather low temperature for fermentation which, with too little sugar present, results in too little acid and favors the development of undesirable coli and butyric acid, rather than the desirable lactic acid, organisms.

Thus when immature crops like alfalfa before bloom or at beginning bloom, are ensiled, having a dry matter content of from only 18 to 22 per cent, a considerable amount of liquid is pressed out of the forage and drains away. The actual dry matter percentage loss usually is small, perhaps ½ per cent, seldom going beyond 3 per cent of the dry matter. However, this dry matter being soluble represents the most easily digestible constituents. The loss of protein in such cases is slight; that of carbohydrates and ash, greater. The palatability as well as the nutritive value is lower in such silage of high moisture content than it would be if the excess moisture were first evaporated or were absorbed by dry feed, preferably ground grain ensiled with the green forage. This leads us to a consideration of the biological processes that make up the sequence of silage fermentation.

How Ensiling Preserves Green Forage. As green plants are put into a silo, the living plant cells continue to respire, using up the available oxygen of the air with the production of primarily heat and carbon dioxide. The more air is entrapped in the forage, as in the case of partly dry forage, the longer is respiration continued and the higher is the resulting temperature. But usually after about 5 hr the oxygen of the air is used up, prompting the living cells to use the oxygen of the plant tissues themselves. This is so-called intracellular respiration, therefore an anaerobic form of respiration, which also has as by-products heat and carbon dioxide, also certain amounts of acid and alcohol. Enzymes within the plant tissues likewise are at work, breaking down some of the nutrient material including protein. There is also some bacterial growth in the juice from the crushed forage.

During the increasingly higher temperature created by these processes and after the exhaustion of readily available material within the plant tissues, the cells die. In the subsequent exudation of cell sap, the bacteria that were originally present in large numbers on the surface of the forage develop at a rapid rate, feeding on the dead cell contents. If these now contain plenty of sugar, or if sugar or other readily fermentable carbohydrates have been added for the bacteria to feed on, there usually results a desirable fermentation, this being a lactic acid fermentation. An acidity of about pH 4.2, when quickly and uniformly established in the silo rather effectively prevents undesirable fermentation.

On the other hand, if the ensiled forage is very wet and readily available carbohydrates are absent, the lactic acid bacteria find it difficult to subsist, and to a large extent give way to the butyric acid and other bacteria that break down protein in their attempt at deriving energy for growth purposes, with the result of producing ill-smelling silage, low in acidity. Such silage frequently is produced at fairly low temperatures, usually not rising above about 90 F. Somewhat higher temperatures, rising beyond 100 F, favor the lactic acid organisms which are more heat resistant than are the butyrics. This will be referred to again later.

In addition to the production of acid, proteolytic end products, and slight amounts of alcohol, there is also some activity by yeasts and molds, which latter fungi, however, cease growing with the disappearance of free oxygen trapped in the silage material.

If now there has been sufficient sugar in the green forage, which sugar by anaerobic means has been converted to acid, with the acidity somewhere around pH 4 or slightly higher, this green forage is sufficiently well pickled or preserved to keep satisfactorily for many months or years. It will have good color and odor. The assumption is that outside air meanwhile has been effectively kept from entering the silage, otherwise molding and rotting take place.

"Ideal" Silage Crops. Corn and sorghum are relatively high in sugar and low in protein and make near-ideal crops for the silo. Millions of lactic acid organisms are adhering to the surfaces of the leaves and stalks of the forage as it is being ensiled, and within a few days they convert the fermentable carbohydrates into acid that makes for excellent preservation. The best corn silage in the observations at Wisconsin has been made when the kernels on the ears had just finished denting and when most of the leaves were still green. At this stage the green corn had a dry-matter content of about 30 per cent.

Any legumes, like soybeans, that ripen at about the same time as corn, or sorghum, suggest themselves for ensiling with these crops, and may be ensiled successfully in various proportions, as equal parts, or one part of one and two parts of the other. Weeds ensiled with corn are utilized better than can be done in any other way. Also weed seeds are effectively killed in the silo.

Legume or Mixed Legume-Grass Silage and Its Problems. In the case of alfalfa or other legumes, also in the case of some grasses, there is a low sugar and a high protein content, therefore the reverse of what we have in corn and sorghums. In consequence, the lactic acid organisms have a less favorable environment. Too frequently the butyric organisms, also the coli and other putrefactive organisms, gain the upper hand with the result of ill-smelling, "sour", unpalatable silage. Butyric acid spores from such silage escape digestion in the digestive tract of cows, and unless cleanliness in milking is observed may cause excessive gas formation in the production of certain kinds of cheese, if the milk is used for that purpose.

What are we to do by way of helping the lactic acid bacteria? Obviously if we feed them what they need for their balanced ration, namely, sugar or other readily fermentable carbohydrates, or if we provide a means for raising the temperature of the green forage to over 100 F, which favors the lactic over the butyric organisms, the former are enabled to gain the upper hand in the struggle for survival within the silage mass.

Wilting Method. At least some of these requirements for making satisfactory silage from (*Continued on page 390*)

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legumes or mixed legumes and grasses are met by partial drying or wilting in the field. By this means, the fermentable carbohydrates seem to be concentrated to a certain extent; at any rate, the green forage is sufficiently dry as to bulk up somewhat more in the silo, thus trapping a certain amount of air which prolongs plant cell respiration in the silo and raises the temperature to a higher level than would have been the case if the freshly cut, succulent forage were immediately ensiled, to result in a water-logged condition which shortens the time of plant respiration. When preservatives are scarce or high-priced, the wilting method, or letting freshly-cut forage lie in the swath for 2 or 3 hr in the sun, or several times as long as that during cloudy weather, is the method to be recommended. Crops in late bloom when they may have 30 per cent or more dry matter should not be wilted but rushed to the silo immediately after being cut in the field. Even without preservatives, a forage having from 30 to 40 per cent or slightly more dry matter makes at least fair silage, provided that the ensilage cutter is set for a short cut and the material in the silo is well distributed and tramped. It is then also more important than with succulent forage that the silo walls be air tight.

Ground Grain or Other Absorbent. If instead of wilting a succulent early growth of forage, some 150 to 200 lb ground corn or other ground grain are added per ton of green forage, thus raising the dry matter to around 30 per cent, a favorable condition is provided for the lactic acid organisms. They appear able to convert some of the starch into acid. Furthermore, on account of the presence of ground grain, the resulting silage is more palatable for the livestock.

Molasses or Acid. Or if a liberal amount of sugar, as carried by molasses is added to the green forage at the time of ensiling, the lactic acid organisms can in that way feed and multiply and produce the preservative acid. Or if acid is added direct to the forage, as through the addition of phosphoric acid or the mixture of hydrochloric and sulphuric acids, which is done in the A.I.V. process, the required acidity is automatically established. By such means best preservation of carotene is obtained. In any event, it is best not to have green forage ensiled in such a high state of succulence as to result in a considerable loss of liquid, which carries away some of the richest or most digestible parts of the forage. This distinctly does not mean that a crop should be mature, perhaps in the late-bloom or past-bloom stage, before it is ensiled, for by that time the crop has lost much of its protein, carotene, and other valuable nutrients.

While at present there seems to be a trend away from the use of preservatives, experiments and farm observations have proved their value. Most farmers making grass silage are aware of the need for a preservative and would willingly use one if it were reasonably cheap and conveniently mixable with the forage.

Inoculation. The use of germ preparations on freshly cut forage in the silo has in Wisconsin tests not proved effective in bringing about better preservation. Green forage as ensiled is seeded with millions of microorganisms, including lactic acid bacteria, and it is far more important to provide favorable conditions for growth of those already present in abundance than that a certain inoculum of such organisms be applied periodically during the progress of filling.

Use of Salt. Adding 5 to 10 lb of salt per ton of green alfalfa has in Wisconsin tests made no noticeable improvement in the acidity or carotene preservation in the silage, but has been observed to improve slightly the palatability of alfalfa silage.

Filling the Silo; Length of Cut; Packing. Where good preservatives for grass silage may of necessity not be used, we may find the following procedures helpful: (1) Ensile succulent early growth slowly, if possible filling two adjoining silos by alternating every day or half day. Use the longest possible cut or even no cut at all, so as to reduce the amount of liquid exudate. A long cut or uncut forage traps that much more air, thus favoring cell respiration and a rise in temperature which, up to a certain degree, is favorable for proper fermentation. This also suggests that such very green, chopped forage preferably should not be tramped in the silo but left to distribute itself by coning up in the center of the silo and toppling over during the progress of filling. (2) Ensile mature growth, or wilted forage, rapidly. Wilted forage or unwilted mature and therefore fairly dry forage is inclined to bulk up in the silo and trap too much air, with the result of excessively high temperature, severe destruction of carotene and other nutrient material, and development of mold growth. For ensiling such material having a moisture content of only 65 per cent or less, the ensilage cutter should be set for the shortest possible cut, preferably a quarter-inch cut which packs the material more tightly with less air spaces. The knives should be kept sharp and nicely adjusted to the shear plate. The silo should be filled rapidly to put as much of the material under pressure as quickly as possible. Practically speaking, one cannot apply too much pressure to such comparatively dry forage. This objective of heavy compacting would be aided by having a man or two in the silo to distribute and tramp the chopped material. All of these factors — rapid filling, the short cut, and thorough distributing and tramping — cut down the amount of air that is entangled in the relatively dry forage and prevent excessive heat and nutrient losses.

Aside from the question of length of cut for best preservation, dairy cows have indicated their preference for a relatively short cut in corn silage, that is, a 1/4 to 3/8-in cut. The greener or leafier the forage, the longer the cut can be and still suit the cow. Early growth of grass or legume can even be uncut.

Field Harvester Problems. Unless a field chopper is equipped with a pickup device for ensiling wilted forage (or for chopping thoroughly field-cured hay in windrows), no wilting can take place between the time of mowing in the field and putting the chopped forage in the silo. Hence it is necessary to cut the crop at the right stage — not too succulent, for then there would be an excessive loss of liquid and a poorer quality of silage. On the other hand, as emphasized previously, the crop should not be too mature and dry, for with tall coarse forage it may not be as easy as with a stationary ensilage cutter to obtain a short cut which enables the silage to pack better, thus reducing the amount of air in the material.

The use of corn-and-cob meal or ground grain of any sort may during early season grass silo filling absorb sufficient moisture to prevent escape of liquid and to improve greatly the quality of the resulting silage. Adding 200 lb of corn-and-cob meal to a ton of succulent grass with 23 per cent dry matter, which therefore under pressure would lose liquid, will raise the dry matter to about 30 per cent where little or no liquid is lost.

The use of from 150 to 200 lb of hay or other dry roughage as absorbents for surplus moisture has in several Wisconsin trials given rather good results, although not resulting in as palatable forage as when ground grain was used.

"Small Batch" Problem. It has been hoped all along that surplus pasture during peak production of early June, or relatively small tonnages of surplus pasture at other times of the growing season, might be cut in the field and put into a silo. But the practice of ensiling small batches, or ensiling several times during a season, perhaps weeks apart, presents a problem of heavy top spoilage. To make possible the successful ensiling of small tonnages of this sort, a convenient temporary seal and pressure device is needed. Some years ago the author proposed the general idea of a rubberized fabric or other watertight bag, easily filled and emptied of water by pumping and siphoning, and of a size suited to the diameter of a silo, to provide the pressure which is a definite factor in the preservation of silage. This has not to our knowledge been actually tried anywhere.

Storage. The nutritive value of silage is little affected by the particular silo used, whether pit, trench, or tower silo, so long as the container keeps air from entering the silage. However, pressure is a helpful factor in controlling the amount of air trapped in the forage, and consequently the amount of respiration, with its resultant heat. Hence a wilted or relatively dry forage suggests itself for a tower silo better than for a trench silo, unless the latter were to be covered immediately with a heavy layer of soil. Merely considering the quality of the bottom layer of silage in a tower silo, drainage is of little importance. A dirt floor is satisfactory.

Baling fresh grass or alfalfa and stacking this material rather tightly in stacks of 9 to 15 tons has resulted in a lot of moldy and rotten material in tests at the University of Wisconsin and the Oxford University School of Agricultural Engineering. The wastage in both cases seemed to be even greater than is incurred in ordinary stack silage.

Palatability. The palatability of the forage that is put into the silo rather than the preservative used (Continued on page 392)

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determines the palatability of the silage. Too much faith should not be put into the particular agent used for preservation, whether this be molasses, phosphoric acid, A.I.V. acid, powdered or evaporated whey, ground grain, or any other preservative. Most grass silages are not as palatable as corn silage, which is one of the most, if not the most, palatable of all silages, even though not containing very large amounts of protein and carotene.

Effect on Livestock. While cattle and other livestock fed good hay get along very well without silage in their ration, it may be taken for granted that really good hay is a scarce article on the average farm. To be sure there is also too much spoiled or low-quality silage throughout the country. But it may safely be stated that where grass silage and hay are compared, the grass silage on the whole is the better roughage. This fact has impressed itself upon the author when comparing grass silage with hay made from the same field during the same haying season on a number of farms in southern Wisconsin.

In many cases, deficiency diseases in young stock toward the end of winter may be avoided by supplementing the ordinary coarse and discolored hay with grass silage which compared with hay far more often has its carotene and other protective nutrients preserved. Consumers of milk from cows fed silage, whether corn silage or grass silage, enjoy this added protection of high carotene and vitamin A content of the milk. Well preserved grass silage has increased the vitamin A content of milk from 50 to 100 per cent over that of milk produced on ordinary winter rations.

On the average farm, silage for reasons stated may be expected to increase milk production as well as increase the food value of the milk. Dairy cows have readily eaten and have thrived on rations containing either hay or silage as the only roughage. That being the case, it is easily appreciated that various proportions of hay and silage are satisfactory. Frequently about the same amount of dry matter is fed by way of the two roughages, therefore about 1 lb hay to 3 lb silage. But in the case of grass silage, frequently two or three times that amount of silage is fed, or therefore 6 or 9 times by weight as much silage as hay. It is held that at least a little sun-cured hay is desirable in the winter to provide the antirachitic vitamin D, unless the cattle are exposed fairly frequently to outdoor winter sunshine.

While silage is more commonly fed to dairy cattle than other livestock, it is well known that beef cattle, sheep, and horses do well on it. In recent years grass silage is mentioned more and more as part of winter rations of brood sows and chickens.

SUMMARY

Acidity in silage tells more about quality in silage than any other chemical test.

High temperatures in silage are destructive of nutrients, but a temperature up to a level of about 100 F may at times be helpful in providing satisfactory silage.

Because of being mostly a matter of respiration, the temperature may be largely controlled by the maturity of the crop, by wilting, by length of cut, by rate of filling, and by packing or compression.

The greener or more succulent the crop, the longer the cut can afford to be, also the slower the rate of filling and the less the amount of tramping. The reverse is true with a relatively dry or mature forage. It is almost impossible to pack this too tightly.

Only when suitable preservatives are scarce or high-priced is the wilting method to be recommended.

The use of salt or inoculation as an aid to preservation has been ineffective.

The type of silo is important only in so far as it excludes air and provides means for compression of the silage.

Drainage is not important so far as quality of the silage is concerned.

A field chopper harvesting succulent grass makes ground grain as a moisture absorbent desirable.

Silage in rations increases milk production on the average farm. Properly prepared silage increases the vitamin A content of milk from 50 to 100 per cent.

Small silos equipped with pressure devices for processing extra leafy grasses and legumes suggest themselves for providing high-carotene winter feed for pigs and poultry.

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is a machine with mechanism already built into it, that if removed it would increase the capacity of that machine at least 10 to 60 per cent.

Since some two-row planters have over 200 separate pieces solely for the purpose of checkrowing corn to obtain a more effective control of weeds, there seems to be a distinct challange to all cultivator engineers. If the 200 pieces were taken off and added to the cultivator, making a cultivator that could control weeds in the rows, a definite contribution would be made to agriculture.

DATA ON TIME CONSUMED BY CHECKROW PLANTER USING BOTH TENSION METER AND PAYOUT STAKES

	Tension meter		Payout stake	
20 rods	3½ mph	5½ mph	3½ mph	5 mph
Stake setting time, min	1.00	1.00	1.5	1.5
Planting time, min	1.08	.76	1.07	.75
Total time, min	2.08	1.76	2.57	2.25
	1.76		2.25	
Time saved, min	0.32		0.32	
Increase, per cent	15.8		12.5	
Stake setting of total time, per cent	48	57	58.3	67.6
Planting time, per cent	52	43	41.7	32.4
40 rods				
Stake setting time, min	1.00	1.00	1.50	1.50
Planting time, min	2.15	1.50	2.15	1.50
Total time, min	3.15	2.50	3.65	3.00
	2.50		3.00	
Time saved, min	0.65		0.65	
Increase, per cent	20.6		17.8	
Stake setting of total time, per cent	31.8	50	41.1	50
Planting time, per cent	68.2	50	58.9	50
60 rods				
Stake setting time, min	1.00	1.00	1.50	1.50
Planting time, min	3.24	2.26	3.24	2.26
Total time, min	4.24	3.26	4.74	3.76
	3.26		3.76	
Time saved, min	0.98		0.98	
Increase, per cent	23.2		20.6	
Stake setting of total time, per cent	23.6	30.7	31.7	39.8
Planting of total time, per cent	76.4	69.3	68.3	60.2
80 rods				
Stake setting time, min	1.00	1.00	1.50	1.50
Planting time, min	4.30	3.00	4.30	3.00
Total time, min	5.30	4.00	5.80	4.50
	4.00		4.50	
Time saved, min	1.30		1.30	
Increase, per cent	24.5		22.4	
Stake setting of total time, per cent	18.9	25.0	25.9	33.3
Planting of total time, per cent	81.1	75.	74.1	66.7
100 rods				
Stake setting time, min	1.00	1.00	1.50	1.50
Planting time, min	5.39	3.78	5.39	3.78
Total time, min	6.39	4.78	6.89	5.28
	4.78		5.28	
Time saved, min	1.61		1.61	
Increase, per cent	25.2		23.4	
Stake setting of total time, per cent	15.7	20.9	21.8	28.4
Planting of total time, per cent	84.3	79.1	78.2	71.6
120 rods				
Stake setting time, min	1.00	1.00	1.50	1.50
Planting time, min	6.48	4.52	6.48	4.52
Total time, min	7.48	5.52	7.98	6.02
	5.52		6.02	
Time saved, min	1.96		1.96	
Increase, per cent	26.2		24.6	
Stake setting of total time, per cent	13.4	18.1	18.8	24.9
Planting of total time, per cent	86.6	81.9	81.2	75.1
140 rods				
Stake setting time, min	1.00	1.00	1.50	1.50
Planting time, min	7.55	5.28	7.55	5.28
Total time, min	8.55	6.28	9.05	6.78
	6.28		6.78	
Time saved, min	2.27		2.29	
Increase, per cent	26.6		25.1	
Stake setting of total time, per cent	11.7	15.9	16.6	22.1
Planting of total time, per cent	88.3	84.1	83.4	77.9
160 rods				
Stake setting time, min	1.00	1.00	1.50	1.50
Planting time, min	8.60	6.00	8.60	6.00
Total time, min	9.60	7.00	10.10	7.50
	7.00		7.50	
Time saved, min	2.60		2.60	
Increase, per cent	27.1		25.8	
Stake setting of total time, per cent	10.4	14.3	14.9	20.0
Planting of total time, per cent	89.6	85.7	85.1	80.0

A Buffalo Grass Seed Drier

By L. C. Aicher

EQUIPMENT for rapidly drying large quantities of seed had to be developed if the new program of vernalization of buffalo grass seed to step up germination was to be accepted generally by producers and dealers. In fact, the maximum utilization of this valuable grass hinges upon proper treatment of seed and a practical method of drying the seed after treatment. The normal germination of newly harvested buffalo grass seed ranges from 7 to 10 per cent. This natural dormancy must be broken by seed treatment to bring about satisfactory germination. The best treatment thus far found to break this dormancy consists of soaking the seed for 24 hr in a 0.5 per cent solution of saltpetre, chilling in a refrigerator for six weeks at a temperature of 40 F while moist, and then drying immediately when removed from the refrigerator.

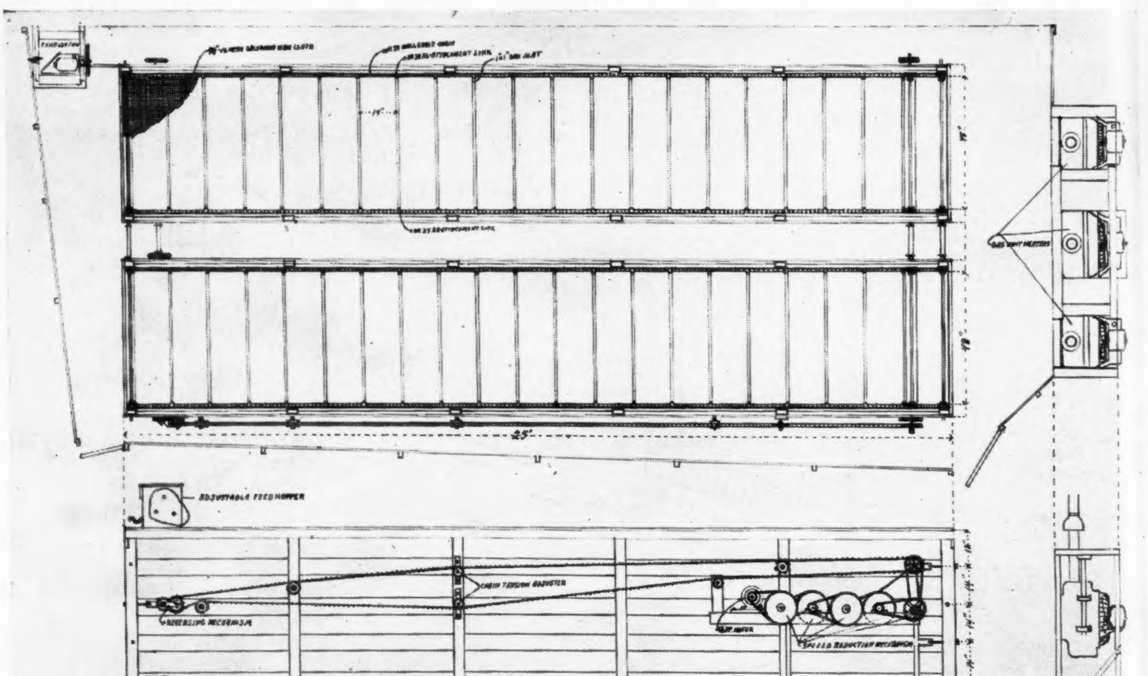
A rotary drying machine was constructed at this station in the fall of 1942 for the purpose of drying buffalo grass seed and considerable seed was dried with the machine, but it lacked capacity and satisfactory control. Much useful information, however, was obtained during its operation which proved helpful in developing the drier described in this article.

The Fort Hays buffalo grass seed drier consists of two units each having four slow-traveling screen wire cloth conveyors over which hot dry air from gas unit heaters is forced to remove the moisture from the wet seed. These two drying units were contained in one large enclosure, in one end of which was installed an exhaust fan to remove the moisture-laden air. In the opposite end intake openings were provided for hot air supplied by three gas unit heaters. The seed to be dried is dropped on the top conveyor screen through two 42-in adjustable-roll feed hoppers.

Conveyor Construction. Two frames 6 ft in height, 4½ ft in width and 25 ft long were constructed of 2x4 and 1-in lumber. Four pairs of 1-in oak strips 24 ft long, for top and bottom slides upon which the chains of the 4-ft screen wire conveyor units rest and slide, were mounted (*Continued on page 396*)

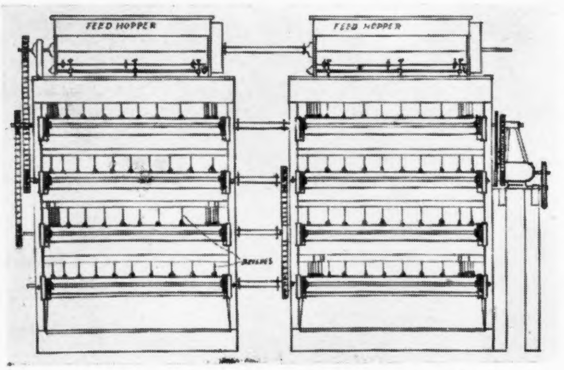
This paper was prepared expressly for AGRICULTURAL ENGINEERING. Contribution No. 41 of the Fort Hays Branch of the Kansas Agricultural Experiment Station.

L. C. AICHER is superintendent, Fort Hays Branch, Kansas Agricultural Experiment Station, Hays, Kans.



Top and side views of the Fort Hays buffalo grass seed drier

(Continued from page 394)



End view of the Fort Hays buffalo grass seed drier

at proper places on the inside of both sides of each frame unit.

Number 34 malleable link chain was used in making up the 4-ft wide endless belt type of conveyors. Right and left malleable attachment links, respectively, were inserted at 14-in intervals along the right and left side conveyor chains. One-inch square oak slats 4 ft long were bolted to the under side of these attachment links. This underside mounting was deemed necessary to prevent excessive strain on the screen wire cloth.

Bearings for the four conveyor shafts were installed at each end of each frame as follows: (1) The top conveyor bearings were placed in the upright 2x4's forming the end of the frame and 12 in below the top of the frame. (2) The bearings for the number two conveyor were dropped down 14 in below the top conveyor bearings and staggered back 16 in from the end 2x4's. This required the insertion on each side of each frame of a two-foot piece of 2x6 to strengthen the frame and at the same time provide material in which to make a 4-ft slot wide enough to permit the bearing housings to slide. Chain tightener adjusting bolts were attached to these bearing housings to take up slack in the conveyor chains. (3) The bearings for the number three conveyor were placed in the same upright 2x4's in the end of the frame in which the top bearings are located and 14 in below the number two conveyor bearings. (4) The number four conveyor bearings were located 14 in below those of number three, vertically under and installed in the same manner with tightener adjusting bolts as those of the number two conveyor bearings.

The bearings on the opposite end of the frames were installed in similar manner to those above noted, except that the top and number three conveyor bearings were staggered back 16 in from the end of the frames and the number two and number four bearings were installed in the upright 2x4's in the end of the frame.

Four 15/16-in shafts with two sprockets on each were installed in the bearings at each end of each frame. The chains with slats attached were then put in place and tighteners adjusted. These conveyors were then run several hours to stretch the chains and break them in a little. After this breaking-in process the 4-ft galvanoid screen wire cloth was carefully unrolled in position on the conveyor slats and tacked to the slats, care being exercised not to get it on too tight in event of additional stretch in the malleable chain which might break the wire.

By staggering the location of the conveyors within the frames and reversing the direction of travel of the number two and number four conveyors it was possible to assemble the equivalent of a 100-ft conveyor within the space of 25 ft in each frame. When the seed traveling on the screen reached the end of the top conveyor, it dropped off on to the number two conveyor and in turn to number four where it was carried to the end and dropped to the floor. The seed was dry when it dropped off the last conveyor and was then shoveled into bags. It was originally planned to install an auger type conveyor to elevate the dried seed into bags, but the operator had plenty of time to handle the dried seed so the auger was omitted.

All the conveyors were run at the same speed and were timed to travel the full length of the 25 ft in 30 min. Hence, the time required for the seed to travel the full length of all four conveyors, from the moment the wet seed from the feed hoppers first dropped on the top conveyor screen until the seed dropped off the bottom conveyor as dried seed ready to be sacked, is two hours. The capacity of the twin-framed drying unit during the months of February, March, April, and May, with much snow, rain, and damp cloudy weather, was 100 lb of dried seed per hour. It was found more economical to run the drier 24 hr per day, each attendant working a 12-hr shift.

Driving Mechanism. In order to run the conveyors at the proper speed it was necessary to arrange for a speed reduction of from 1725 rpm on the ½-hp motor to 50 rph on the conveyor shaft. This was accomplished by making up a speed reduction unit of several series of pulleys and sprockets. Four sets of V-belt pulleys with pulley ratios of 3 in to 12 in on the driver and driven, respectively, and two sprocket-wheel units were installed. The first sprocket combination consisted of an 11-tooth sprocket on the driver and a 38-tooth sprocket on the driven. Changes to get the desired speed for the conveyor were then made on the last set of sprockets. The final sizes provided were a 10-tooth sprocket for the last driver and 30 teeth for the last driven sprocket, the latter turning the shaft of the conveyor.

Brushes. Eight sets of brush units of fifteen brushes each were installed above each conveyor to stir the seed as the conveyor moved along. By staggering every other row of brushes all the seed on each conveyor is moved eight times while in transit from one end of the conveyor to the other. This frequent stirring exposed all of the seed on the conveyor to the hot dry air passing over the screens and thereby hastened drying. The brushes are made of fiber hence do not damage screen wire cloth over which they continually rub.

Feed Hoppers. Two Clipper adjustable-roll feed hoppers each 42 in wide were installed to feed the wet buffalo grass seed on to the screen wire cloth conveyors. By removing all shafts and gears from these feed hoppers, except the one used to actuate the feed roller, it was possible by belting direct to one of the conveyor shafts to operate the rollers at optimum speed. The shafts operating the two rollers were united by means of a flexible-joint connection thereby permitting both rollers to be operated from the same drive pulley. The roll feed hoppers handled the properly cleaned and processed seed very satisfactorily. One lot of poorly cleaned seed required considerable adjusting of the roll feed hoppers.

Heat and Temperature. A battery of three unit gas heaters potentially delivering a total output of 275,000 Btu per hr were installed at one end of the drier enclosure to furnish the heated air to dry the buffalo grass seed. These ran continuously for 24 hr per day and consumed an average of approximately 325 cu ft of gas per hour. The efficiency of the heating units could be considerably increased if the enclosure could have been made of wood or insulation material. At the time construction work was done only sheet metal was available.

The temperature inside the drier varied with the temperature and humidity of the outside air and the amount of air removed from the enclosure. However, satisfactory drying of the seed was accomplished when the temperature inside the enclosure was 90F or above.

The highest temperature permitted inside the enclosure was 126 F which occurred on May 17, a warm sunshiny day with outside temperatures around 80 F. When the inside temperature of 126 F was reached, one of the gas unit heaters was cut off to avoid injuring the seed.

A 12-in exhaust fan operated by a ¼-hp electric motor was used to remove the moisture-laden air from the enclosure. During the cold months it was difficult to get the temperature in the enclosure much over 100 F but satisfactory drying was accomplished. An auxiliary fan was installed to aid in removal of the moisture-laden air in spring and summer. It could not be used, however, during the cold weather because it lowered the temperature inside the enclosure and reduced the efficiency of the drying unit.

Moisture Reduction. The soaked buffalo grass seed when taken out of the refrigerators to be dried contained approximately 83 per cent of moisture by weight on the dry basis. From 80 to 83 per cent of this moisture was driven off during the drying process, depending upon the temperature reached inside the enclosure. More could have been driven off if the amount of seed being fed on the screen conveyor had been slightly reduced. The dried buffalo grass seed containing from 14 to 16 per cent *(Continued on page 402)*

EVERY rat that can get into his cribs or bins eats or spoils 150 pounds of grain a year, according to government figures. If he boards 14 rats—and many farmers have more—he's lost the market price of more than a ton of grain. Worse, he has also lost the time and labor spent growing and harvesting it.

Consider then the labor and money that farmers save with steel storage buildings. All losses—rats, fires, winds—average less than ½ of 1 per cent.

TIME IS A CROP. Steel bins and cribs illustrate the point that you have been stressing with your farmer friends for years—that time is their most valuable asset. Today you may be advising them on planning their winter time. Or you may be helping manufacturers develop even more efficient farm equipment . . . or prefabricated steel buildings scientifically designed to house livestock and store crops safely at low cost. Many of these products will last longer, look better and require less upkeep because they will be made of Armco *special purpose* sheet steels.

FOR BETTER EQUIPMENT. For instance, ARMCO ZINCGRIP is a special zinc-coated sheet that can be severely formed or drawn without peeling or flaking of the coating. It has been widely used in stock tanks, poultry equipment and formed parts of farm machinery.

Another steel, ARMCO Galvanized PAINTGRIP, has a special Bonderized coating that takes and preserves paint. It has proved its worth in combines, corn pickers and other painted farm equipment. For further information on Armco *special purpose* sheet steels, write to The American Rolling Mill Company, 3271 Curtis Street, Middletown, Ohio.

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NEWS SECTION

A.S.A.E. Meetings Calendar

December 6, 7 and 8 — Barn Hay Curing Conference (sponsored by Southeast Section), Andrew Johnson Hotel, Knoxville, Tenn.

November 16 — Pennsylvania Section, State College, Pa.,

February 19 and 20 — Southeast Section, Atlanta, Ga.

June — Annual Meeting.

Barn Hay Curing Conference

THE Southeast Section of the American Society of Agricultural Engineers, in cooperation with the Society's Committee on Hay Harvesting and Storage, is sponsoring a three-day conference on barn hay curing to be held in Knoxville, Tenn., December 6, 7 and 8. The conference sessions will be held at the Andrew Johnson Hotel. Non-members as well as members of A.S.A.E., interested in the subject of the conference, will be welcome.

Hotel reservations in connection with this conference should be made direct with the hotels — and as early as possible. Suggested hotels and their rates are as follows: Andrew Johnson Hotel — single, \$2.75 and up; double, \$4.95 and up. Farragut Hotel — single, \$2.50 and up; double, \$4.00 and up. Arnold Hotel — single, \$2.50 and up; double, \$3.50 and up.

On the first day of the conference, December 6, an inspection trip is being arranged for all those interested to visit a typical farm installation for barn curing of hay near Knoxville. All who expect to take this trip should notify C. J. Hurd, Tennessee Valley Authority, Knoxville, in advance.

Both the forenoon and afternoon sessions of the conference on the second day, December 7, will be devoted to round-table discussions of the principles of barn hay curing, covering such pertinent phases of the subject as duct system design for loose hay, operation and management, use of artificial heat, drying chopped hay, drying baled hay, and hay quality.

A meeting of the A.S.A.E. Committee on Hay Harvesting and Storage is scheduled for the evening of the second day.

The forenoon session of the third day, December 8, will be devoted to round-table discussions of equipment for barn curing of hay which will be led by representatives of the manufacturers of such equipment, and will cover fans; motors, magnetic starters, and time switches; distribution facilities, dealer participation, and engineering assistance; manufacturers' descriptive and advertising literature, and forecast on production and deliveries of equipment for 1945.

The afternoon session will be devoted to a round-table discussion on educational and field plans, to be led by representatives of agricultural extension services, electric power distributors, and other agencies working with farmers, and will cover interstate cooperation in furthering the hay drying program, present procedure by which farmers may secure equipment, etc.

Printed copies of the program and other information about the conference will be mailed to members of the A.S.A.E. Southeast Section and to members outside the territory of the Section believed to be interested in the subject of the conference. Other members and all non-memers may obtain this information from C. J. Hurd, T.V.A., Knoxville, Tenn., or from the A.S.A.E., St. Joseph, Mich.

Clyde Heads North Atlantic Section

AT its meeting in New York City, September 26 and 27, the North Atlantic Section of the American Society of Agricultural Engineers elected A. W. Clyde, professor of agricultural engineering, Pennsylvania State College, as chairman of the Section for the ensuing year, succeeding R. G. Harvey of the Central New York Power Corp. J. F. Schaffhausen, agricultural engineer of Johns-Manville Corp., was elected vice-chairman, and G. L. Munroe, rural service engineer, Narragansett Electric Co., secretary-treasurer.

In point of attendance (148 registrations), excellence of program, interest, etc., comments of those in attendance voted the meeting as outranking any previous one held since the Section was organized in April 1925. The new officers have already begun to lay plans for the Section meeting in 1945.

New A.S.A.E. Section

MEMBERS of the American Society of Agricultural Engineers residing in Pennsylvania have been recently authorized, by Council of the Society to organize the Pennsylvania (state) Section. Arrangements are being made for the organization meeting to be held at State College, Nov. 16.

Personals of A.S.A.E. Members

T. N. Jones was recently separated for mthe Army, in which he was serving as Major in the Field Artillery, and has returned to his duties with the Mississippi Agricultural Experiment Station, where he is now head of the station's agricultural engineering department.

Norton Ives recently resigned as extension agricultural engineer at the University of Minnesota to accept appointment as assistant extension agricultural engineer in the Iowa Agricultural Extension Service.

Edwin A. Krekow, associate engineer, at the Denver office of the Bureau of Reclamation, U. S. Department of the Interior, has been transferred to McAllen, Texas, where he now carries the title of "agricultural economist" and is in charge of the economics section of the Valley Gravity Canal and Storage Project.

R. O. Pierce has resigned as associate civil engineer, engineering section, Farm Security Administration, and now holds the position of irrigation engineer with the Soil Conservation Service of the U. S. Department of Agriculture, and is located at Holdrege, Nebraska.

E. C. Sauve and *E. G. McKibben*, section of agricultural engineering, Michigan Agricultural Experiment Station, are authors of an article, "Studies on Use of Liquid in Tractor Tires: Part I. Effect on Traction and Change of Pressure with Variation in Weight Carried by Tires," appearing in the quarterly bulletin of the Michigan station for August 1944. Reprints of the article are available on request to the station.

L. J. Smith, chairman, agricultural engineering division, Washington Agricultural Experiment Station, is one of the authors of Bulletin No. 445 recently issued by that station, entitled "The Jeep As a Farm Truck-Tractor for the Postwar Period."

J. Phelps Walker has resigned as a member of the agricultural engineering staff at Virginia Polytechnic Institute, and is now engaged as planning technician for the Montgomery Work Unit, U. S. Soil Conservation Service, at Christiansburg, Virginia.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Vernon C. Belt, technical staff, Bell Telephone Laboratories, Inc. (Mail) 106 Maple St., Summit, N. J.

Fred Cassidy, executive engineer, Wood Bros. Thresher Co., 1700 E. Aurora Ave., Des Moines 13, Iowa.

Paul A. Deleon, chief engineer and manager, food processing division, Cleaver Brooks Co., Milwaukee, Wis. (Mail) 4200 N. Larkin St.

John H. Denton, manager, Valley Rural Electric Cooperative, Inc., Box 397, Huntington, Pa.

William A. Dodd, Jr., 2nd Lt., Corps of Engineers, USA. (Mail) P O Box 6770-A, Chicago 80, Ill.

Edward H. Faulkner, director, modern farmer program, National Broadcasting Co., Station WTAM. (Mail) 427 9th St., Elyria, Ohio.

Dan M. Guy, agricultural engineer, Ethyl Corporation, 1600 West 8 Mile Road, Detroit, Mich.

C. E. Jakway, manager, Claverack Electric Cooperative, Inc., Towanda, Pa.

Daniel C. McCoy, manager, commercial section, product development and application department, Frigidaire Division, General Motors Corp. (Mail) RR No. 7, Dayton 9, Ohio.

Robert M. Morgan, irrigation layout and design specialist, R. M. Wade & Co. (Mail) 7917 S. E. 32nd Avenue, Portland 2, Ore.

Barton W. Moses, manager of rural electric co-op, Hancock Co. R.E.M.C., Greenfield, Ind. (Mail) 318 Walnut St.

Walter E. Ripper, managing director, Pest Control, Ltd., Harston, Cambridge, England.

Vernon Vine, associate editor, Farm Journal, Washington Square, Philadelphia 5, Pa.

TRANSFER OF GRADE

Thomas E. Long, assistant agricultural engineer, North Dakota Agricultural Experiment Station, Fargo, N. D. (Mail) 1135 - 9th St., North, (Junior Member to Member)

Hugh C. Smith, manager, farm use sales department, The Sisalkraft Co. (Mail) P. O. Box 62, Wayne, DuPage Co., Ill. (Associate to Member)

Earl F. Thompson, assistant soil conservationist (engineering), Soil Conservation Service, USDA. (Mail) 48 Stanley St., Mount Morris, N. Y. (Junior Member to Member)

GIVE YOUR HARVEST A LIFT *Electrically*

On the James Long Farm, St. Johns, Mich., a homemade grain and ear-corn elevator driven by an electric motor elevates six bushels of oats a minute. Essentially, the elevator consists of wood flights nailed on a three-ply, 3-in. rubber belt. At the left are Ed and Jim Long. To date, Ed has built more than 50 of these elevators for other farmers in his community.

A 20-ft ear-corn and grain elevator made from Diagram 3 (offered below).

You can make your own elevator. We will send you complete working plans.

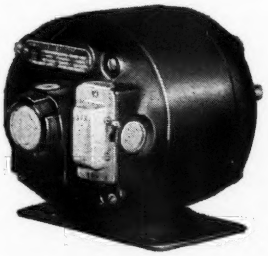
Whether you are storing grain or ear-corn, an electric elevator to lift your crop into storage bins will handle more bushels per hour with less effort than you ever believed possible. With fewer hired hands available, the need for more electrically driven equipment becomes increasingly apparent.

To help you build an elevator, perhaps this winter when you have more time, General Electric offers you diagrams—working plans—drawn up by Michigan State College, Department of Agricultural Engineering. They are free for the asking—simply send in the coupon below, with your choice marked. *General Electric Company, Schenectady 5, N. Y.*

FOUR TYPES AVAILABLE

1. Grain elevator—10 ft to 24 ft, portable
2. Ear-corn elevator (same as above)
3. Combination grain and ear-corn (same as above)
4. Vertical—built-in, bucket type for permanent use indoors

Complete dimensions, list of materials required, full explanation of each type included. These have been tested and approved in actual operation.



G-E fractional-horsepower motor recommended for use on these elevators. It can be used on other equipment—in the workshop, in the home. For further information on this and other G-E motors for the farm, ask for Bulletin GEA-4187.

Farm Industry Division
General Electric Company
Schenectady 5, N. Y.

Please send me diagram(s) I have checked below:

☐ 1. Grain elevator
☐ 2. Ear-corn elevator
☐ 3. Combination grain and ear-corn elevator
☐ 4. Vertical, bucket-type elevator

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Postwar Needs in the Field of Farm Power and Machinery

POSSIBILITIES in interchangeable power units for farm machines is something that merits special study in the postwar period, according to a report made recently by the Committee on Postwar Planning of the Power and Machinery Division of the American Society of Agricultural Engineers; in fact, the report recommends the formation of a committee representing engine and machinery manufacturers to undertake the standardization of engine and machine parts for the purpose of making interchangeable power units feasible.

Inasmuch as some farm machines and implements or parts thereof are known by different names, the Committee recommends the appointment of an A.S.A.E. committee to study nomenclature of farm machinery and equipment and formulate definite recommendations in connection therewith.

In its report the Committee also recommended that agricultural engineers in war service be circularized to learn their desires as to postwar employment, etc., as a preliminary step in assisting in the most effective placement possible after the war of agricultural engineers now serving with the armed forces.

In addition to the foregoing recommendations, the Committee gave consideration to other worth-while postwar projects but made no specific recommendations in connection therewith. These matters are as follows:

The Committee believes that farm living conditions should be made more attractive to returning soldiers, especially with respect to improvement in housing conditions.

Farming units should be consolidated the Committee believes, to the extent of making one out of about four of the present units, thus providing a higher level of management and better returns from the land. The consolidated units should not be too large, and it believed that the system proposed should maintain a semblance of the family farm, but result in greater economies than the present system.

The Committee would like to see special study given to the distribution of war equipment suitable for farm use. It is also of the opinion that more attention should be paid in the postwar period to the training programs for teachers of vocational agriculture and to agricultural extension work. Also, because so much labor has been drawn away from the farm for direct or indirect participation in the war effort, much of which will not return to the farm, thus resulting in a smaller percentage of workers in rural areas after the war, the Committee believes that such a situation will stimulate the demand for labor-saving equipment and practices, and that agricultural engineers should be giving special attention to that situation.

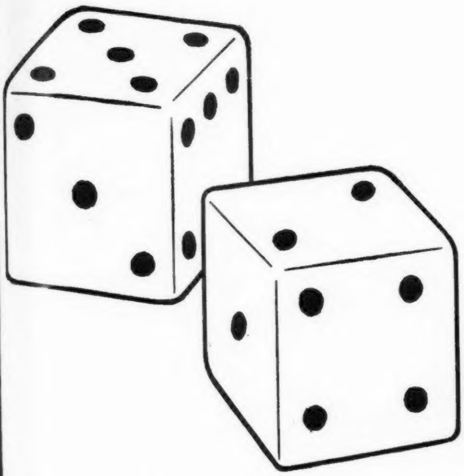
The personnel of this Committee included A. J. Schwantes (chairman), E. M. Mervine, D. A. Milligan, R. I. Shawl, B. G. Van Zee, and F. J. Zink.

A Buffalo Grass Seed Drier

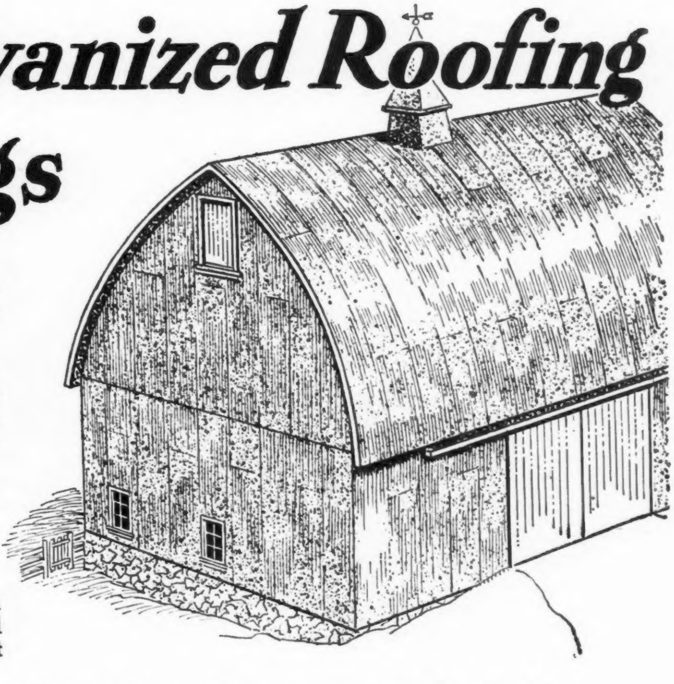
(Continued from page 396)

of moisture was stored in jute bags in the warehouse, and when moved out two months later the seed containing 16 per cent was found to have lost approximately 2 lb per 100 lb. All seed was in perfect condition. When the temperature reached 122 F inside the enclosure, the dried seed was found to contain 14 per cent moisture.

Germination. After the seed was dried samples were taken to determine germination. The seed before treatment had germinated from 7 to 10 per cent. Good well-matured and properly cleaned seed germinated 75 to 80 per cent after treatment. Some of the same seed left in the refrigerators for eight weeks germinated 85 per cent. Other lots of seed not well-matured and not well-cleaned germinated 50 to 65 per cent, depending upon quality. Experience to date indicates that the proper treating and drying of buffalo grass seed increases germination from six to eight times that of untreated seed.



It's GOOD LUCK to have Galvanized Roofing on Buildings



For in these days of material scarcities, galvanized roofing can be taken care of by simple, easy means and made to last a lifetime.

Galvanized roofing is zinc-coated roofing; and the U. S. Bureau of Standards states that zinc is "by far the best" protective metallic coating for iron or steel! Zinc in the form of galvanizing provides double protection:

First, by simple coverage, with a sheath of rust-resistant metal.

Second, by electro-chemical action or "sacrificial corrosion."

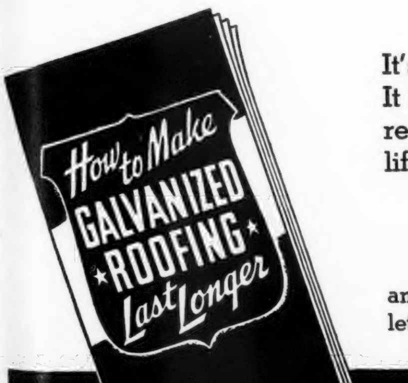
Galvanized roofing is used on more than a third of all the farm buildings in the United States — which proves that farmers are smart judges of roofing value!

Take Care Of It!

It's just good business to take good care of galvanized roofing. It is so easy to do it, too, that there's no excuse for neglect. With reasonable care, galvanized roofing can be made to give a lifetime of satisfactory service. Get a copy of the free booklet

"How to Make Galvanized Roofing Last Longer"

and the few simple steps to take will be made completely clear. The booklet is valuable. It's free—write for it today.



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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any Notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

FARM STRUCTURES MAN wanted by large company for expanding program in prefabricated farm buildings and components. Excellent opportunity for man qualified in functional phase of design and promotion. Replies should indicate scope of training and experience. Confidential. PO-167

SALES ENGINEER wanted for permanent position with small company producing well-accepted building material products. Substantial base salary, better than average proposition for man with liking for sales work and knowledge of building construction. Give full information on past experience and earnings expected. PO-166

AGRICULTURAL PRODUCT ENGINEER wanted for mechanical designing and development of corn pickers, combines, and other harvesting machines. Permanent position with old well-established midwest manufacturer with national distribution. Located in fine city with adequate housing and educational facilities. Big postwar farm market assures future. Salary open. Good opportunity for advancement. Write experience, qualifications, draft status, and other particulars in your letter. PO-165

ENGINEERING AIDS needed in federal agencies. Persons to perform subprofessional engineering work in civil, topographic, photogrammetric, mechanical, and other branches of engineering are being sought to fill federal jobs in Washington, D.C., and in other parts of the country. The salaries range from $1752 to $3163 a year, including overtime pay. Appointments will be made in the Geological Survey, Department of the Interior, Coast and Geodetic Survey, Department of Commerce, and Department of Agriculture, and application forms may be secured at first and second-class post offices or direct from the U. S. Civil Service Commission, Washington 25, D. C., or from the Commissions's regional offices.

AGRICULTURAL ENGINEER wanted by a well-known national organization to engage in sales promotion work on farm buildings, preferably someone in his early thirties with good engineering training and farm background and with plenty of initiative and ingenuity. Special training in farm buildings would be helpful to person selected. Discharged service men will receive special consideration. Write giving full details as to education, experience, etc. PO-164

(Continued on page 408)

THE SLEEPING GIANT

America's motorcar industry has been at war. When it gets back to making automobiles, a vast new opportunity for engine improvements will be waiting in the improved gasoline that will then be available.

HIGH ON THE LIST of things the average man wants after the war is a new automobile. But John Public looks forward to something more than just a *new* car—he wants a *better car*.

It is true that replacements for essential transportation may keep the automobile industry more than busy for quite awhile after the war. During this period revised versions of 1942 models may be all that are available. Once this phase of reconversion is over, there will be the problem of continuously rebuilding and replacing America's automobile population—and again the problems of "creating" sales and customers in a competitive market. We can look forward to future engineering competition along the lines of the simple, time-honored, American method of making better and better cars.

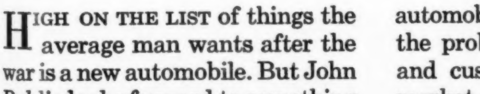
Refinements in body design, new accessories and greater riding comfort will play their part. But the most significant progress in motorcar design will depend—in the future, as in the past—*upon the development of engines that get more work from each gallon of gasoline.*

The basis for such progress already exists. It lies in the development of engines to fully utilize the greatly improved gasoline which the petroleum industry will be in a position to offer the public.

ETHYL CORPORATION

Chrysler Building, New York City

Manufacturer of Ethyl fluid, used by oil companies to improve the antiknock quality of aviation and motor gasoline.



Wartime progress by America's petroleum industry has paved the way for fundamental progress in post-war automobile engine design.

EMPLOYMENT BULLETIN

(Continued from page 406)

SALES ENGINEERS, preferably 32 to 38 years of age, with college education in engineering and with sales experience, are wanted by a large national manufacturing organization to engage in the sale of farm buildings through dealers. While a postwar project, qualified applicants will be interviewed now. Special consideration will be given discharged service men who have qualifications sought. Write giving full particulars as to education, experience, etc. PO-163.

POSITIONS WANTED

AGRICULTURAL ENGINEER available. Six years' experience in rural electrification with private power company and government power project; experience in educational and research phases of the work. Two years' experience in farm management with state institution. Well acquainted with personnel of the land-grant colleges in midwest and southern states. Two years' experience as mechanical engineer and plant supervisor for large industrial concern. B. S. degree from a Midwest university. Age 32, health excellent, married. PW-363

AGRICULTURAL ENGINEER with a B. S. degree in agricultural engineering from an eastern college is available for employment. Experience in soil conservation, drainage, and use of explosives in land drainage and land clearing; farm reared with experience and knowledge of the operation, care, and adjustment of farm machinery and equipment, also wood-working equipment and farm building construction. Age 38, married, two children. Would like position in teaching, research, or extension work. PW-362

AGRICULTURAL ENGINEER with a B. S. degree in agricultural engineering from a midwest college and training course in management, operating and buying with mail-order firm. Two years experience in farm building appraisal, inspection and fire prevention. Present position, purchasing and planning of aircraft parts. Age, 27 years; married with two children; draft status, 2B. Would like position in development and promotion of farm buildings and equipment or in purchasing or production work in a factory manufacturing agricultural equipment. PW-361